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MEDICINE.—*Andreas Vesalius.*[1]

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(Communicated by WILLIAM A. DAYTON.)

We commemorate this year the 400th anniversary of the publication by Andreas Vesalius of a textbook on human anatomy. This recognition, however, is not in gratitude or respect for the anatomical facts that he set forth or for the benefit to humanity in his or subsequent centuries derived directly from the knowledge he gave of the structure of the human body. This gratitude and this recognition stem from a source far deeper and far more fundamental. Vesalius was one of that glorious group of revolutionary leaders whose conflicts were not with armies on the battlefield, not for territorial gains or national integrity, but for the fundamental right of men to see and hear and, seeing and hearing, to believe the evidence of their own eyes and their own ears. With his scalpel in the dissecting room he fought alone for the liberty of human thought. Anatomy was only symbolic: his field of endeavor might have been religion or philosophy—it might have been any field of learning. The weapons used by the great leaders who have given us the democracy of thought and the democracy of belief—who have given us intellectual independency and dignity—and the fields in which they used these weapons matter little; what do count are the battles they have won in a common cause. Do not view Vesalius as a man who added only to the store of human knowledge by telling us the structure of the body; view him primarily as one who helped to give us freedom of thought and opinion; do not view his *Fabrica* as an historical monument to anatomy; but view it as a monument to the struggle for truth.

These words of mine which I use for preface would, if they had been said to Vesalius, have sounded strange—grandiloquent—yes, they would have sounded silly to him. He was a simple and outspoken man who could not stomach intellectual dishonesty, who had breached the dignity of his own profession—and that profession was the lowest branch of medicine—breached it by pushing away the barber who, before the class in anatomy, did the mutilating dissection at the haughty direction of the professor who deigned to touch the body. Vesalius, I am certain, would never once have thought of himself as struggling for man's intellectual independence. I am equally certain that he did not imagine himself in a struggle of any greater magnitude than that, say, of convincing his teacher in Paris, Jacobus Sylvius, that he, Sylvius, did not know the true anatomy of the body and that he, Vesalius, did. If Vesalius had felt himself a hero, or had counted himself a fighter in a struggle above the level of the dissecting room, he would have shown an egotism that appears nowhere in his writings or his actions. It is we who, four centuries later, with the advantage of hindsight, can look back and give a value to his work that he and his contemporaries could not have given. To him and to them his one virtue was his correction of anatomical errors and the presentation of splendid anatomical illustrations. Today, there are far better anatomical textbooks than that of Vesalius, and his illustrations are now only artistic medical curiosities; da Vinci, years before, made drawings that

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were as good. As an anatomist, Vesalius is of mild historical interest; his *Fabrica*, as a specimen, is a fine book, but not a great book. His greatness and its greatness are not in their intended purposes and ends, but in their influence in breaking down a tradition that forced an unreality on human thought—not alone in anatomy but in all medical thought.

I have used the words "tradition that forced an unreality on medical thought." Let us now, before we turn to the life and work of Vesalius, examine something of the structure of that tradition.

As we view medicine over the long expanse of time, one fact stands out beyond all others: medical progress is rare. The usual state of medicine is one of stagnation and sterility in which, century after century, no new fact, no new application, is made; the essence of this stagnation and sterility has always been a philosophical concept that has, with its ready-made answers, stifled the curiosities of men, made them content with the knowledge they possessed in the belief that they held the ultimate answers. Medicine progresses only when there is dissatisfaction—when ignorance is admitted.

The first great sterilizing influence on medicine—one that held sway from prehistoric times—was that which combined medicine and religion. This combination was the inevitable result of the belief that diseases, indeed all the misfortunes of man, were due to supernatural influences exercised at the wills of spirits, gods, and demons. Under such a belief there was no incentive and no reason to seek the cause of disease since the cause was known. All that man could do was to devise better magic to influence the supernatural creatures or more clever tricks to outwit them. Under this belief man assumed no responsibility for his physical salvation; that responsibility was placed on the spirits or gods or demons who controlled his destiny and who held disease in their hands as a slave driver holds a whip.

This ancient tradition of primitive medicine was carried on into the early civilizations. The philosophy was not altered, dissatisfaction did not develop, and ignorance was not admitted. The alterations were all in the externals. The healing temple took the place of the tent or cave of earlier times; the priest took the place of the savage medicine man; and the crude and simple spirits that appealed to the savage mind were reincarnated as the regimented gods and demons and heroes whose names and lives are familiar to us from mythology.

The first break in this priestly healing, and consequently the first known period of medical progress, came in the classical period of Greece. Prior to this break, the Grecian medicine was in the hands of the priests of Aesculapius. The ministration to the ill was in the great and magnificent temples devoted to this god. In the statues to him there he was represented as carrying in his hand a staff about which twined a single snake that remains the emblem of the physician even to this day. Represented with him was his daughter whose name, Hygeia, has given us the English words "hygiene," "hygienic," and "hygienist." The name of his other daughter, Panacea, which now means a cure for all diseases, has never found a respectable place in modern medicine and, with the passage of our Federal food and drug laws, has diminished in repute even in the field of proprietary medicaments.

However rigid an impediment to medical progress, as we understand that progress, the Grecian healing religion may have been, the priests themselves were men of dignity and highest integrity. The code of their ethics has, like the caduceus of Aesculapius, come down to the physician of today; this code was incorporated in a temple oath; it later was called the oath of Hippocrates, and many a doctor of our day, on graduating from medical school, has sworn to this ancient oath.

The symbolism in emblem, word, and ethics is all that we have retained of this priestly medicine. But it was among its priests that modern medicine was founded. In the Age of Pericles, headed by a man—or he may have been only a name—Hippocrates, there developed the first scientific and progressive medicine of which we have any certain knowledge. Under this new medicine, man became responsible for his

own salvation on earth; his problems were capable of solution at his own hands; and he must seek the solution. Under this philosophy, which brushed aside the fatalism of spiritualistic medicine, there began the sound observation by which alone the physical nature of man could be discovered; by which the causes of his diseases could be found out and the remedies obtained. There was dissatisfaction with existing knowledge, there was frank confession of ignorance, and there was deep determination to obtain knowledge. And also there was intellectual freedom. No man was an authority so great that his word must be taken as the truth; instead, truth was to be found in the evidence of eyes and ears and touch and integrated with a clear and unbiased logic. This period was the great one of medicine; it stood out as a mountain peak, to whose heights men did not rise again for 18 or 19 centuries.

Under Roman conquest the descent began; and, with the Fall of Rome, it was complete. Men in later days, with the renewal of culture, could again have climbed up to the peaks of ancient greatness if the way had been open, but in those closing years of the Roman period, a barrier—the tradition which I mentioned earlier—was built across the way. This was the Galenic tradition. It was the tradition of authority. It was the second great obstacle to the progress of medicine, an obstacle that by ready-made answers stifled the curiosities of men in the belief that they held the ultimate answers; it closed their eyes and ears in the blind and deaf faith in authority.

The physician Galen, after whom this tradition is named, lived in the second century A.D. He was a man of great ability; he was the founder of experimental physiology, and to him are due basic discoveries in anatomy and diagnosis. But, unfortunately, he was also the most voluminous medical writer of ancient times—dangerous in itself and devastatingly so in this instance since Galen was also the greatest theorist and systematist. We know of 9 books on anatomy; 17 on physiology; 6 on pathology; 16 essays on the pulse and therapy; 3 books on temperament; and 30 on pharmacy. He differed from Hippocrates in that instead of simple observation and interpretation he followed a pragmatic system of medical philosophy. His postulates were based on the humoral ideas of Hippocrates, the Pythagorean theory of four elements, and his own invention of a spirit or "pneuma" permeating the body. Using these postulates with great ingenuity, he explained every phenomenon of health and disease in the light of pure theory. He had a mania for teleology, which he may have gotten from Aristotle whom he took as his authority. Aristotle had said that Nature makes nothing in vain—that is, every creature serves a purpose and is designed for that purpose.

Unquestionably structure follows function in the adaptation of any living creature to its environment. But it was not Galen's purpose to show the adaptation. Rather he sought to show that fitness to the environment was a manifestation of the goodness of the Creator. As Neuberger has put it: "Galen made his whole physiological theory a skillful and well-instructed special pleading for the cause of design in Nature, whereby he lost himself in *a priori* speculation in attempting to explain Nature's execution before even her mechanism had been demonstrated." And, as Garrison says: "He never really sought *how* an organ functions but in blind obedience to Aristotle he reiterated the transcendental *why* which Kant and Bernard have pronounced forever insoluble."

His ready-made answers, his polypragmatism, his reason for every phenomenon, his purposefulness, his monotheism and piety, his assumption of omniscience, all appealed to the Moslems who, for a time, carried the torch of learning; and they appealed also to the Church, which dominated the thought of Europe during the next 1300 years. Up to the time of Vesalius, everything in anatomy, physiology, diagnosis, therapy, and medical theory was referred to Galen as the final authority. It was an authority from which there could be no appeal. To deny it might, and did, lead to death for heresy. Thus the Galenic tradition of enforced authority was the barrier to medical progress; it was the barrier that was breached by Vesalius; and from this breaching the way was opened for modern

medical progress. From the days of Vesalius we date the second great period of medical advancement—the period in which you and I are fortunate to live, and to which many of us here owe our lives.

Whether Galen had made any dissections of the human body we shall never know. Probably he had not. At most he may have had an occasional glimpse at interior structures and some study of some human bones. The anatomy that he wrote of was that of the ox, the ape, and the hog. But in his writings this fact is not stated; it is man about whom he appears to be writing and to whom he gives a miscellaneous assortment of organs from the brutes. Man, according to Galen, had the abdominal muscles of an ape, a 4- or 5-lobed liver, seven segments in the sternum, and two bile ducts, and the female had a double-horned uterus. Galen further postulated minute pores in the septum which separates the right and left sides of the heart through which the blood was supposed to seep, and he found joint lines in the jaws where none were ever found afterward. These anatomical misfits and vagaries were, to keep an anatomical metaphor, the heel of Achilles in Galen's authoritative writings, and to them there was added, or subtracted as you will, by the scholastics of latter days, a difference in the ribs of man and woman dating from the birth of Eve.

These scholastics did not follow the simple and obvious procedure of running their fingers over the ribs to count them, but instead, in solemn discussion with ancient authority—not their own observations—as premises, they did gymnastics with logic. And from this exercise they derived the state of man's ribs, and they believed their conclusions as implicitly as they believed the teleology, of which they were indeed an integral part. Vesalius, in contrast, was one of those rude and practical people who outraged the ethics and formality of scholasticism by feeling and counting the ribs and believing what he felt and counted. The incredible blindness of scholasticism, the belief in authority rather than in fact, is summed up for me best in a statement attributed to a philosopher whose name I can not recall. He was being shown some structure of the body during an anatomical dissection; the structure differed from the authoritative description. His serious and considered statement in this dilemma was, in effect: "I should be inclined to believe the evidence of this demonstration if Aristotle had not stated specifically to the contrary."

It is difficult for us who have been emancipated in most matters from this type of thinking to realize what a hold it can have upon the human mind. But the freedom of our way of thinking is as cultivated a one as that of blind obeisance to authority. It is kept alive by continual cultivation. In a generation with other schooling we could revert to the subservience to authority and be willing to deny the evidence of our own eyes and ears. We see something of this in the political and racial views of a generation that has grown up today in Germany. We may call it fanaticism; in reality, however undesirable it seems to us, it may be a more natural and innate way of human behavior than is our democracy of thought.

Now in the days between Galen and Vesalius, there were anatomists of repute and there were anatomical dissections of a sort. But these anatomists, in the dissections they demonstrated, recorded nothing to controvert Galen; if some glaring inconsistency forced itself upon them, they brushed it aside with the statement that the body had changed since Galen described it.

When the first medical school was founded in Europe at Salerno, anatomy was taught, so we are told, from dissections of the hog. The restorer of human anatomy in medical education was Mondino of Bologna. In 1315, acting under royal authority, he gave a public demonstration of anatomical dissection with readings from Galen. In this, and in all subsequent dissections until the time of Vesalius, the medical student, the physician, and the professor did not do the dissecting. The spectators sat or stood in the dissecting room; the professor occupied a pulpit upon which rested the books of Galen; the subject for dissection was on a table in front and beneath this pulpit; the crude dissection was done by a barber with an instrument as large as a cleaver.

Mondino wrote a textbook of anatomy

which was issued in manuscript form in 1316 and was printed in 1478. It was the standard textbook in all Italian universities. It contained no new facts but was compiled from Galen and the Arabic commentators of Galen. In fact, much of the nomenclature was Arabic. According to his description, the heart was in the center of the body. The valves were, to quote, "a wonderful work of Nature," but beyond this pious exclamation of admiration there was no description of their function. The blood, according to the observations of Mondino, followed precisely the course described by Galen in that it passed through the septum between the right and left side. He says: "To the end that the blood which comes to the left ventricle from the right, be refined, because its refinement is the preparation for the generation of vital spirit." I use this quotation because this question of the movement of the blood was one of the major points at which the demonstrations of Vesalius broke the Galenic tradition. When he showed that the blood did not pass through the septum, this finding could not be dismissed on the ground of an anatomical variation or of an alteration in structure since the days of Galen. The passage was basic to Galen's whole concept of physiology. Destroying this basis cast doubt not only on Galen's anatomical observations but, far more important, it cast doubt upon his whole thesis of function. The structures of the body might vary; it was obvious that they did in gross anatomy as between different men; similarly, they might have altered since the days of Galen. But it was inconceivable that fundamental physiology varied or that it had altered since Galen. The structure was only the building that housed the microcosmos; function—the operation within—had a more fundamental significance.

The anatomists who worked between the time of Mondino and Vesalius added some details to the knowledge of bodily structure but none disagreed with Galen. That is, none if we except Leonardo da Vinci. He believed that a knowledge of artistic anatomy could be gained only at the dissecting table. He probably knew Galenic anatomy and that of Mondino, but he was his own teacher. He left more than 750 sketches of bodily structures, strikingly accurate and magnificently presented. He was the first creative anatomist, but he had no influence on the Galenic tradition. He recorded his marginal notes in the secretive spirit of the times in minor writings. When Vesalius published his *Fabrica*, and for two centuries afterward, Leonardo's drawings were lying unpublished, first as the cherished possession of his favorite pupil Melzi, later in the Ambrosian Library at Milan, and still later forgotten in the Royal Library at Windsor.

There is one other student of anatomy to mention before I come to Vesalius. He is Albrecht Dürer. He did nothing to shake the Galenic tradition, but in his publication on human proportions he made the first attempt to represent shades and shadows in woodcuts by means of crosshatching. This, in turn, may have had an influence—and this is speculation—upon the work of Titan's pupil van Calcar, who made the magnificent wood engravings for the *Fabrica* of Vesalius.

Now as to the man himself. Andreas Vesalius was born in 1514 under the name of Wesalius; the V was substituted for the W in the family name in 1537. Three weasels were prominently displayed on the coat of arms of the family, suggesting that previously the family name, which was Whiting, had been changed to that of the locality that the family claimed as its native place —Wesel in the Duchy of Cleves. In the family there was a long line of prominent physicians who practiced in the courts of the period or taught in the universities. Andreas's father was, throughout his life, apothecary to Charles V and to Margaret of Austria. I mention this court connection because it was the father who, on Andreas's early retirement from anatomy, obtained for him a place in the court of the Emperor.

And finally, we know from astronomical observations made by Jerome Cardan that Andreas was born at 6 o'clock in the morning and under favorable stellar influences. As a youngster he was sent to the University of Louvain, which then was second in number of students only to that of Paris. Here Andreas obtained an extensive training in Greek and Latin, learned much of Arabic, and something of Hebrew. But tir-

ing of these dialectics, he, for reasons we do not know, turned to the study of anatomy. The writings of the church fathers, as approved of in the highly orthodox university, gave him little substance for the study. For an independent, searching mind no satisfying anatomical knowledge could be gleaned from Albertus Magnus and Michael Scotus. And we are told by his contemporaries that he soon discovered that the only true text of anatomy was the opened body. We are told further that he dissected, as has many an inquisitive boy, the bodies of mice, moles, rats, dogs, and cats.

In 1533, at the age of 19, he went to the Mecca of all medical students—Paris. The most notable feature of the medical education at Paris was that it had successfully removed the errors which the works of Galen had suffered at the hands of the Arabic translators. Paris taught pure Galen and taught it with a fervor for the orthodox as great as any theological institution of the period. Of the teachers of great repute whom he met in Paris, I mention only one because of the conflict that arose later. That one was Jacques Dubois, better known as Jacobus Sylvius. He was noted for his industry, his eloquence, his command of abusive language, and, above all, for his avarice. The last of these qualities is testified to by his epitaph, which reads:

SYLVIUS LIES HERE, WHO NEVER GAVE
ANYTHING FOR NOTHING:
BEING DEAD, HE EVEN GRIEVES THAT
YOU READ THESE LINES FOR NOTHING.

Sylvius started out in life as a philologist, but his desire for wealth led him to abandon this field and take up medicine. Before he had obtained a degree, he began a course of medical lectures explanatory of Galen and was so successful that the University of Paris protested. Consequently, in 1529 at the age of about 50, he went to Montpellier and obtained his degree. Returning again to Paris be became a free-lance teacher and again with such effect on university attendance that the authorities ruled that he must once more stop since, so it seemed, he had failed to obtain a bachelor's degree before his doctor's degree. He took two years off to satisfy this requirement and then, since there could be no further legitimate protest, he emptied the benches at the university as the students flocked to his eloquence. Sylvius died in 1555 and, to save funeral expenses, was interred in the paupers' cemetery. I have read his epitaph.

In justice to Sylvius it should be said that he was the first professor in France who taught anatomy from human dissection. But it was dissection after the method of Mondino. Never did Galen have a more devout follower than Sylvius. He declared that: "Galen's anatomy was infallible, that his physiology was divine; and that further progress was impossible." And Sylvius, with his great learning and equally great command of abusive language, was no man to be questioned by the 19-year-old Vesalius, who listened to his lectures and watched with distress as the barber mangled the anatomical specimen. It is said that in sheer desperation the young student sometimes pushed away the prosectors, took the knife in his own hands, and carried out a systematic dissection. Recognition was given to his ability by one of his teachers, Guinter, who said of two of his students: "First, Andreas Vesalius, a young man, by Hercules, of singular zeal in the study of anatomy; and second, Michael Servede, deeply imbued with learning of every kind, and behind none in his knowledge of the Galenic doctrine." As to Michael, there was never a more ironic word than that of his devotion to Galen; he was the Michael Servetus who later, in showing an error of Galen, antedated Harvey in postulating the circulation of the blood and who, for a theological quibble, was burned at the stake by order of Calvin and whose books were burned with him. Vesalius succeeded by good fortune where Servetus failed.

In Paris, Vesalius made numerous dissections and he became a master of the bones of the body. This latter knowledge was not gained from his professors but in the cemeteries, where, as in the grave digger's scene in *Hamlet*, with the crude burials of the times, bones often found their way to the surface.

In 1536—after he had been in Paris three years—the Franco-German War broke out and Vesalius went to the University of

Louvain. Soon after his arrival he obtained the famous skeleton whose theft is always portrayed as the dramatic episode of his life. At Paris he had searched for bones in the cemeteries; in Louvain he visited the gallows outside the city walls and searched on the ground. It was there that he found, not on the ground but on the gallows, a skeleton that was held together by the ligaments and that still possessed the origin and insertion of the muscles. It is said to have been the skeleton of a famous robber who had been roasted to death and then picked clean by the birds. There, above the eyes of the young anatomist, was what he had never seen before, a complete and articulated human skeleton. In the past he had tried to make one by piecing together the bones from many skeletons, gathered from different places but this was a prize, He climbed the gallows, stole the skeleton, and carried it home. One finger, a knee cap, and a foot were missing. Again, at night, he stole out of the city and searched among the decaying bodies until he found the missing bones.

Such dangerous and secret expeditions as this soon became unnecessary, for the burgomaster of Louvain agreed to furnish Vesalius and his students with anatomical material. It was from Louvain that he began his career as an author but not on anatomy; he published a translation of an Arabic work on general medicine. He conducted public demonstrations of anatomy, but some remark of his concerning the seat of the soul caused theological criticism and threat of formal charges. This threat brought caution, and caution brought dissatisfaction. He left Louvain and, in 1537, traveled to Venice.

Here the study of anatomy was actually encouraged by the Theatin monks, who devoted their lives to the care of the ill. At the head of this order was a young man of great strength of character and vision, Ignatius Loyola, who was to become the founder of the Jesuit order, which was accepted by the Pope in the same years that Vesalius published his *Fabrica*. Another fortunate meeting for the young anatomist was with his countryman Jan Stephen van Calcar, student of Titian who was to make the drawings for the *Fabrica*. In December of the same year that he reached Venice, 1537, Vesalius received his degree of doctor of medicine and almost simultaneously was appointed professor of surgery with the right to teach anatomy in the University of Padua.

From manuscripts of the period we have a fairly clear idea of the way in which he taught. The meetings of his classes were in a wooden amphitheater, which accommodated about 500 spectators. Those who attended were not only medical students but also distinguished citizens interested in the science of the times. The course occupied the full day from early morning until evening for a period of three weeks. During this entire time, Vesalius lectured, drew diagrams, and, with the aid of students, made magnificent dissections. No barber helped him. He opened the book and turned the pages, as it were, of the body himself. We have a description of the course he gave in December, 1537. Every seat in the amphitheater was taken, and all standing room was occupied. The professors of the university, officials of Padua, members of the clergy and learned persons of all ranks and positions were there. The crowd extended to the very edges of the dissecting table. Vesalius—then at the age of 23—entered. He made a few remarks as to the general importance of anatomy. Then, by means of a dog or a sheep, he demonstrated the division of the body, the joints, and several sorts of flesh, or what today are called tissues. Next, he turned to the human cadaver and discussed the changes of age and the differences of sex. Then came the dissection, and with each succeeding day there followed a continual demonstration with sketches and pertinent discussion of all collateral medical, physiological, and pathological matters. Such was the success of his courses that in 1539 and 1540 he was called from Padua to Bologna to conduct public dissections. Bologna was the ancient home of Mondino, who, as you will recall, had revived the practice of teaching human anatomy. In Bologna a special amphitheater was erected for the dissections by Vesalius.

In his lectures he could not escape disputations, for the errors of Galen were laid

bare before the audience. Vesalius gave all such disputations a close anatomical basis and avoided all discussion of theoretical physiology. We have an example of this later from the *Fabrica*. There, touching upon Galen's basic theory that the blood passed from the right side to the left side of the heart through pores in the septum, Vesalius says: "We are driven to wonder at the handiwork of the Almighty, by means of which the blood sweats from the right into the left ventricle through passages which escape the human vision." As one of his spectators, you could, in pious faith, accept that on its face value or, as a skeptic, you could read into it what significance you wished.

The culmination of the career of Vesalius at Padua was the publication, in 1543, of the *Fabrica*. It was the result of three years of grueling work and no less of constant vexation with his friend the artist van Calcar, who made the woodcuts. These and the text were taken over the mountains in the summer of 1542 by a merchant named Danoni, who delivered them to the printer, Oporinus, at Basel. With them there was an explanatory letter from Vesalius giving minute details of the way in which he wanted the book printed. Oporinus at once set about having the type cast and the pages composed and printed. In those days the printer was a scholar, and with him there was a group of scholars; he and they took over the task not only of printing but of revising, editing, and rewriting the manuscripts. Early in 1543, however, Vesalius himself came to Basel and followed the book to completion.

It has been suggested in the past that it was Titian himself who made the sketches for the woodcuts. This belief led, in the years following the publication of the *Fabrica*, to its especially high esteem among artists. At the time the woodcuts were made, Titian was over 60 and, although still vigorous, he was too busy and too honored in his established field to undertake the drawings for a youthful anatomist in Padua. Vesalius did not sign the name of the artist in the *Fabrica*, but increasing evidence points to van Calcar. It was he who, in 1538, made the cuts for certain anatomical sheets which Vesalius issued for his students. The drawings are essentially the same as those in the *Fabrica*, as vividly executed and as detailed.

In the *Fabrica*, the drawings vary considerably in merit. Those of the skeleton and of the muscles are the best. Those of the nervous system are of much less merit.

The *Fabrica* consisted of 659 folio pages of text: 34 pages of index; 6 pages of preface; and 2 pages of a letter to the printer, Oporinus.

From our standpoint, there were many unavoidable errors in the anatomical descriptions in the *Fabrica*. As Vesalius maintained—and soundly so—function can be determined only from structure; and therefore it is useless to speculate as to function until the structure is known. But even his eyes were occasionally blinded by those theories of function which he believed were facts. He did not know of the circulation of the blood but assumed, without apparent question, that the blood ebbed and flowed in the veins. Hence the anatomical significance of the valves which he saw in the veins escaped him completely. He considered them mere excrescences that fortunately did not interfere with the flow of blood in either direction.

But such features are carping criticisms. The main point is that Galen had been wrong. Not wrong in details as Vesalius was occasionally, but wrong in plainly observable facts and in easily demonstrable facts. The *Fabrica* was a denial of Galen. The reader could believe Vesalius and his own eyes and ears; or he could close his eyes and ears and believe Galen. The *Fabrica* forced the issue. And if the reader believed Vesalius and his own senses in anatomy, doubt was cast upon all the interlocking system of Galenic medicine.

What is more, the issue now was not before a few interested and sympathetic spectators in an anatomical amphitheater but before the whole world. The *Fabrica* was for all men to read.

If the physician believed Vesalius, then he was forced to throw aside much that he had believed and taught and to stop the veneration of one who, throughout his whole education had been held before him

as the authority—to discredit the saint, the prophet, the dictator of medicine. Men do not easily change so radically in matters that would touch them deeply, that would shake them from the mental security of an orderly and satisfying system of beliefs. The intellectual labor of making the change bewilders them. To discard what they have believed and to follow the teachings of another touch upon their egos. Their emotions rise; and the height of the rise is often an indication of depth to which the instrument has probed their convictions. Sylvius, the teacher at Paris, he of the vituperative tongue, was a leader in the opposition. He spoke of Vesalius as Vesanus (a mad man) whose pestilential breath poisoned Europe.

It is from conflict that views are altered. It is only in conflict that sides are taken, that wide interest is aroused. This conflict was essentially an election; men were making their speeches, as it were, for the candidate of truth: Vesalius vs. Galen. And what was most important, many anatomists decided to settle the choice, not by disputation, but by recourse to dissection.

It was in the midst of this struggle that he had precipitated that Vesalius returned to Padua from his year's absence. Padua was seething with the controversy. Some of his own pupils turned against him. The arguments were bitter and personal. Vesalius was a strong fighter, but he was first and foremost an observer and a student. Why should he waste his time in arguing over the existence of what any fool could see with his own eyes? He was disgusted. He went to Pisa in 1544 and conducted a course in anatomy. He declined the chair in that university offered him by the Medici. He was tired of the continuing controversy—sick of disputes and of persecution by members of his own profession. How could he study anatomy when interest was only in him as the center of a storm and in his efforts at defense? In a fit of passion he, at the age of 30, threw his manuscripts into the fire. This gesture ended his career as a scientist. He accepted an appointment as physician to Emperor Charles V of Spain. Gabriel Fallopius, formerly professor at Pisa, and a pupil of Vesalius, was appointed at Padua to succeed Vesalius. Fallopius studied anatomy undisturbed by the storm that still raged about his predecessor. Vesalius was a court physician; his reputation as a physician grew great in Madrid but only in Madrid. The scalpel with which he had made his dissections grew rusty while he treated the maladies of the ladies and gentlemen of the court.

Then in 1561, when he had been 17 years away from Padua, he received a book by Fallopius—a book of anatomical observations. It was a complete confirmation of his work. The battle was won. In Padua, in the world outside of Spain, one could now speak freely against the anatomy of Galen; one could use eyes and ears and believe what one saw and heard. It was now Fallopius who led in anatomy—already men were forgetting Vesalius. That little dart of inescapable bitterness that any human being would have, even amid his rejoicing at the acceptance of his work, is stated deftly by Edith Wharton in her poem "Vesalius in Zante":

> Vesalius? Who's Vesalius? This Fallopius
> It is who dragged the Galen idol down
> Who rent the veil of flesh and forced a way
> Into the secret fortalice of life.

Then, in 1563, Vesalius made a pilgrimage to Jerusalem. The reason is not known. Perhaps it was the restlessness that grew out of reading Fallopius and the fact that Fallopius had died and the chair at Padua was vacant. It may have been a dozen reasons, for Vesalius was an impetuous man. There is a legend—and I have grave suspicions of all legends of medical history—that rests on a letter written in 1565 between two physicians of that period. It says: "Doubtless you have heard that he went to Jerusalem. The journey had, they tell us from Spain, an odd reason. Vesalius, believing a young Spanish nobleman whom he had attended to be dead, obtained leave from the parents to open the body for the sake of inquiring into the cause of the illness which he did not rightly comprehend. This was granted; but he had no sooner made an incision into the body than he perceived the symptoms of life, and opening the breast saw the heart beat. The parents coming afterwards to the knowledge of this, were not satisfied with prosecuting him for

murder, but accused him to the Inquisition of impiety, in hope that he would be punished with greater rigor by the judges of that tribunal than by those of the common law. But the King of Spain interfered, and saved him on condition that by way of atoning for the error he should undertake a pilgrimage to the Holy Lands." Edith Wharton has put it thus:

This pilgrimage
They call a penance—let them call it that;
I set my face to the East to shrive my soul
Of mortal sin? So be it. If my blade
Once questioned living flesh, if once I tore
The pages of the Book in opening it,
See what the torn page yielded ere the light
Had paled its buried characters—and judge!

Whatever the cause may have been, he made the pilgrimage. That was a year, as I said, after the death of Fallopius at Padua and the chair of anatomy was vacant. Perhaps this may have been the cause of the journey. If it was, it bore fruit, but fruit that was never eaten. In the Holy Land, Vesalius received an invitation to resume his old chair at Padua. He shipped for home. A violent storm swept the Ionian Sea, his boat was wrecked on the Island of Zante. There, of a sudden and obscure malady, he died. He died—the author of the *Fabrica*, which Osler says was "the greatest book ever written, from which modern medicine dates."

ECONOMICS.—*Comparison of two methods of estimating capitalized value of earning capacity.*[1] A. J. LOTKA, New York, N. Y.

Estimates of the capitalized value of human earning capacity have been made by two different methods. It is rather singular that no examination has ever been made of the relation between these two methods.

The first method, dating back to William Petty,[2] computes the capital C which, invested at an interest rate i, would yield the total annual earnings E of the population, and then regards

$$C = \frac{E}{i} \qquad (1)$$

as the capital value of the population of N persons (of all ages and both sexes) or C/N as the average value per head of the population.

The second method, developed by William Farr,[3] equates the capital value *of a wage-earner* to the present worth of his net future earnings (i.e., earnings less expense for his own personal maintenance). Denoting the value thus defined by V_a for a wage-earner of age a, Farr's method, expressed in an algebraic formula, gives

$$V_a = \frac{l_0}{l_a v^a} \sum_a^\omega L_x W_x v^{x+1/2} \qquad (2)$$

where W_x denotes the earner's *net* annual earnings at age x to $x+1$ and $v = 1/(1+i)$ is the annual discounting factor to reduce future receipts to their present worth at age x. The symbol l_x, with its usual significance, denotes the number of survivors to age x out of l_0 born (age zero), and L_x is the number of persons of ages x to $x+1$ in a "life table population," so that within linear approximation $L_x = (l_x + l_{x+1})/2$. The symbol ω denotes the limiting age of life. Since l_0 is a purely arbitrary constant (the *radix* of the life table), we can arbitrarily put $l_0 = 1$. Then l_x and L_x, instead of numbers of individuals, represent corresponding proportions. It will simplify our formulae to adopt this convention.

It is at once obvious that Petty's and Farr's estimates can not be quite generally equivalent, since the total value of the population, in the sense of Petty's estimate, must depend on the age distribution, as must also the value per head deduced from it; whereas Farr's estimate of the value of the individual earner does not involve the age distribution of the population, as it applies specifically to an individual of given age.

[1] Received October 16, 1943.

[2] PETTY, Sir WILLIAM, *Political arithmetic, or a Discourse concerning the extent and value of lands, people, buildings, etc.*, p. 192. 1699.

[3] FARR, WILLIAM. Journ. Stat. Soc. London, 1853, p. 43.

The question, however, arises how Farr's estimate, applied to a natural standard population, compares with Petty's applied to the same. Such a natural standard is presented in a so-called life table population, that is, a stationary population maintained, with constant annual births B and an equal number of annual deaths D, under the regime of a fixed life table.

In the stationary population the number of individuals between the ages x and $x+dx$ evidently is $Bl_x dx$. If w_x denotes the average annual earnings at age x per head of the population of both sexes and of age x, then the total earnings of the population will be

$$E = B\int_0^\omega l_x w_x dx \tag{3}$$

or, in linear approximation

$$E = B\sum_0^\omega L_x W_x \tag{4}$$

where

$$W_x = \frac{w_x + w_{x+1}}{2} \tag{5}$$

According to Petty the capital value of the population would thus be

$$C = \frac{B\sum_0^\omega L_x W_x}{i} \tag{6}$$

with W_x in this case referring to *gross* earnings.

On the other hand, if V_x is the average value of an individual of age x, in the sense of Farr (but averaged over all occupations, including unemployed, and both sexes) then the sum[4] of these values for all the individuals of the population is

$$C' = B\int_0^\omega l_x V_x dx \tag{7}$$

or, in linear approximation (trapezoid formula)

$$C' = B\left\{\sum_0^\omega l_x V_x - \tfrac{1}{2} l_0 V_0\right\} \tag{8}$$

and hence, introducing (2), with $l_0 = 1$,

$$C' = B\left\{\sum_0^\omega \frac{1}{v^a}\sum_a^\omega L_x W_x v^{x+1/2} - \frac{1}{2}\sum_0^\omega L_x W_x v^{x+1/2}\right\} \tag{9}$$

$$= B\left\{\sum_0^\omega L_x W_x v^{x+1/2}\sum_0^x \frac{1}{v^a} - \frac{1}{2}\sum_0^\omega L_x W_x v^{x+1/2}\right\} \tag{10}$$

$$= B\left\{\sum_0^\omega L_x W_x \frac{v^{-1/2} - v^{x+1/2}}{i} - \frac{1}{2}\sum_0^\omega L_x W_x v^{x+1/2}\right\} \tag{11}$$

Omitting terms of second degree in the expansion of $v^{-1/2} = (1+i)^{1/2}$, that is, putting $v^{-1/2} = 1 + i/2$ this gives

$$C' = \frac{B\left(1+\frac{i}{2}\right)}{i}\left\{\sum_0^\omega L_x W_x - \sum_0^\omega L_x W_x v^{x+1/2}\right\} \tag{12}$$

or finally, putting

$$\delta = \frac{i}{1+\frac{i}{2}} = \frac{2i}{2+i} \tag{13}$$

$$C' = \frac{B\left\{\sum_0^\omega L_x W_x - \sum_0^\omega L_x W_x v^{x+1/2}\right\}}{\delta} \tag{14}$$

where δ is (in linear approximation) the instantaneous rate of interest corresponding to an annual rate i. Petty's procedure for the same stationary population gives

$$C = \frac{E}{i} = \frac{B}{i}\sum_0^\omega L_x W_x \tag{15}$$

Thus, even in the simple case of a stationary (life table) population, Farr's pro-

[4] We may form this sum in a purely arithmetical sense, without committing ourselves to any physical interpretation; that is, without enquiring in what physical sense, if any, "Farr Values" may be additive.

cedure leads to a result at variance with that of Petty. The nature of the difference calls for examination.

The points of difference fall into two categories. Those of the first reside merely in the kind of data to which the procedures have been applied, namely:

Petty starts from a total *gross* income of a population, and obtains a per capita average for the entire population of all ages and both sexes by dividing by the number of the population.

Farr applies his procedure to the *net* income of individuals *of a specified earning capacity*.

The procedure can, however, be applied equally to the corresponding *gross* income, and this has actually been the plan adopted by A. Barriol.[5] Conversely, if the data were available, Petty's method could be applied to *net* income.

Also, it would be possible to apply Farr's procedure to an average individual representative of all earning capacities and of the two sexes jointly. We shall, in what follows, assume that this is done, and that formula (2) is construed accordingly with reference to net earnings.

Petty's indirect estimate of the earnings of the population as the excess of the total income over the income from property is questionable. Aside from numerical inaccuracies in the data, this method involves an error in principle. The earnings of a man can not be considered apart from the earnings of the capital invested in his inanimate aids to production. The two form one operating unit, and its performance can not be summed up by the mere addition of two items, one for the human labor, and one for the contribution of the machine, plant, etc. Even the contributions of the several parts of a plant are clearly not additive. The productive performance of a motor plus machine tool is not the sum of the performance of the motor alone—this would be zero—plus that of the machine tool alone—this also would be zero. In the same way the productive performance of manufacturing plant without human operators would be zero, and the productive performance of the human operators without the plant, though not necessarily zero, would in the majority of cases be relatively very small. The performance of man plus plant is far from being merely the sum of the performance of man alone plus that of plant alone.

These, then, are incidental differences, which, in principle at least, could in part be removed by suitable selection of data.

There remain three fundamental differences, not arising merely from the nature of the data, but representing inherent defects of Petty's method:

1. Petty's method gives at best an average value per individual of the particular population (having a certain distribution by sex, age and earning capacity) as against Farr's method, which evaluates the individual according to age, the values so obtained being then in turn applicable to any population.

2. Petty's formula as applied to a life table population lacks the term $-B\sum_0^\omega L_x W_x v^{x+1/2}$. He has treated the capital value of the population as a perpetuity, overlooking the fact that actually the population suffers a constant drain through deaths, which, in a stationary population, is replaced by the values of incoming new births.

3. A minor correction to apply to Petty's formula is the introduction of the instantaneous interest rate δ in place of the common interest rate i, to allow for the fact that, regarded as an income-yielding capital, the population brings a continuous income, unlike a loan of money, which brings an income at finite intervals.

These results can be generalized somewhat. Still considering the case of a population with fixed life table and age-specific earning capacity, but with variable annual births (and consequently deaths) let us denote by $B(t-x)$ the annual births at time $t-x$, so that at time t the number of persons of ages x to $x+dx$ will be $B(t-x)l_x dx$. Then, using the instantaneous interest rate δ, the Farr value of the population will be

[5] Revue Économique Internationale, Dec. 1910; March 1911.

$$C' = \int_0^\infty e^{\delta a} \int_a^\infty B(t-x) l_x w_x e^{-\delta x} dadx \qquad (16)$$

$$= \int_0^\infty B(t-x) l_x w_x e^{-\delta x} \int_0^x e^{\delta a} dxda \qquad (17)$$

$$= \frac{\int_0^\infty B(t-x) l_x w_x dx - \int_0^\infty B(t-x) l_x w_x e^{-\delta x} dx}{\delta} \qquad (18)$$

Petty's procedure in analogous application would give

$$C = \frac{\int_0^\infty B(t-x) l_x w_x dx}{\delta}, \qquad (19)$$

which lacks the second term of the result given by Farr's procedure.

PALEONTOLOGY.—Cribanocrinus, *a new rhodocrinoid genus.*[1] EDWIN KIRK, U. S. Geological Survey.

The genus *Rhodocrinus*, in common with other early crinoid genera, has had a great number of diverse forms referred to it. Several genera have been separated from this amorphous assemblage in the past. It is here proposed to erect another genus, *Cribanocrinus*, for the reception of a fairly homogeneous group of species from the lower Mississippian.

Cribanocrinus, n. g.

Synonym.—*Rhodocrinus* (in part of authors).
Genotype.—*Rhodocrinus wortheni* Hall.

Theca. Dorsal cup typically subglobose to urceolate or ovate. Base flattened, depressed or with a well-defined central invagination. Maximum diameter of cup usually at about one-half its height, or lower. The cup contracts distad, having its least diameter at the level of the arm bases. The tegmen is very small, convex, and made up of small plates. The anal opening is at the apex of a relatively small protuberance that can scarcely be dignified by the term anal tube. This protuberance is seldom preserved, and its base may be marginal at nearly the level of the arm bases, or excentric on the tegmen. Owing to the reduced diameter of the cup at the level of the arm bases, the arm groups are closely spaced. They are somewhat more widely separated in the posterior interradius than elsewhere.

Typically the surface of the plates is smooth, except for the customary fine granulation. The plates are convex, becoming tumid in such species as *C. whitei*. In some species there is a low, inconspicuous rounded ridge traversing the radials and brachial series within the cup. In the later species of the Keokuk, Borden, and Warsaw there is a variable development of surface ornamentation consisting of low radiating ridges or irregular rugosities.

IBB. Usually entirely enclosed within the basal pit and concealed by the column. In forms with slight invagination, such as *C. wortheni*, they extend beyond the column.

BB. Very large, may be larger than or somewhat smaller than the *RR*. In the majority of the species the proximal portions of the *BB* are flexed inward, forming the wall of the basal pit.

RR. Large.

IBrr. The first *IBr* is typically quadrangular but may be pentagonal, hexagonal, or even heptagonal. It is relatively small. *IAx* is small and may be either somewhat smaller or larger than IBr_1. In most of the species, even in individuals of maximum size, there is but a single *IIBr* incorporated in the cup. The number of incorporated *IIBrr* apparently does not exceed two in any case.

IRR. The interradial fields are narrow at the base, widen distad, and then narrow. The posterior interradius is appreciably larger than the others. The first interbrachials in all cases rest on the truncated distal faces of the *BB*. Exceptionally in very large specimens, and particularly in *C. wachsmuthi*, two interbrachials may rest on the *post B*. In such cases the second plate appears to be a lateral plate of the second range that has migrated downward within the lifetime of the individual. Usually

[1] Published by permission of the Director, U. S. Geological Survey. Received October 25, 1943.

there are three plates in the second range in the *post IR* and two in the others. Occasionally there is a poorly defined median row of plates in the *post IR*, but this is exceptional. In the other interradii one commonly finds two plates in each range above the second, the increasing and diminishing width of the interradius being compensated for by increased size of the plates rather than the presence of additional interbrachials. At the level of the arm bases the interradial field is narrow, and in some cases is little wider than the space between the arm bases within a radius. No intersecundibrachs have been seen in any species referred to the genus.

Arms. The arms are relatively short and stout, tapering rapidly distad. They are uniserial below and compactly biserial above the bifurcations. The branching of the arms is somewhat variable but falls within a well-defined pattern. The first division of the free arms takes place on the sixth to tenth secundibrach, the number varying even as between the halves of a ray. Several species consistently hold this number of 20 rami. In other species there may be additional bifurcations. One or more of the rami may divide in an arm group, and in some species all do so, giving a maximum of 40 rami. In an occasional radius, in the Kinderhook species, there may be but two rami.

Column. The column is relatively stout, circular in section, and has a small pentagonal lumen.

Geologic and stratigraphic distribution.—The described species of *Cribanocrinus* are found in the Kinderhook, Burlington, Keokuk, and Warsaw of the Mississippi Valley and the Borden of Indiana. It is probable that some European species fall within the genus.

Relationships.—*Rhodocrinus*, as is the case with several of the early crinoid genera, has a very doubtful nomenclatorial status. For the purposes of this paper I treat *Rhodocrinus* according to currently accepted usage, that is, with the type species *verus* based on Miller's (1821) plate 1, figure 2 (opposite p. 107). That this usage may not be valid is admitted. The validation of *Rhodocrinus verus* as based on the specimen indicated will require a ruling from the International Commission of Zoological Nomenclature, if and when that body again functions.

The dorsal cup of typical *Rhodocrinus* has a flattened base. The sides of the cup are nearly vertical, or diverge distad. There may be a slight constriction at the level of the lower fixed brachials and an outward flare above. There are typically three or more secundibrachs incorporated in the cup and intersecundibrachs are present. The interbrachial fields are wide and merge distad into the tegmen. The radials and incorporated brachial series are traversed by strong, rounded ridges, and the interbrachial fields are somewhat flattened, giving the cup a definite pentagonal cross section. Passing from plate to plate throughout the cup are rounded ridges. As viewed from below, one sees a well-defined stellate pattern, formed by these ridges. The tegmen, as seen in an English species nearly allied to the type, is low, with depressed interambulacral areas. As viewed from above, the theca appears definitely lobate.

There are a number of characters in which *Cribanocrinus* differs from *Rhodocrinus*. The lack of ornamentation in the typical group of species of *Cribanocrinus* or its slight development in the later species is one of the most striking differences. The rounded subglobose to ovate cup of *Cribanocrinus* and its constriction at the level of the arm bases is perhaps the most important difference. Stemming from this are: the narrow interbrachial fields, all but cut off from the tegmen; the tegmen greatly reduced in size; and the relatively great size of the basals and radials as compared with the primibrachs. The incorporation of but one or two *IIBrr* in the cup and the concomitant lack of intersecundibrachs in *Cribanocrinus* are likewise important, although, of course, in very young individuals of *Rhodocrinus* the same conditions would obtain.

In the Kinderhook is a group of species that may be referred to *Rhodocrinus*, such as *nanus*, *kirbyi*, and *cavanaughi*. Such strongly ornamented forms, which have other *Rhodocrinus* characters as well, do not pass up into the Burlington, so far as known. No one can doubt the close relationship of the Kinderhook species of *Rhodocrinus* and *Cribanocrinus*, and that they had a common Devonian ancestor. In the Kinderhook species of *Cribanocrinus*, *C. watersianus*, and in the species from that horizon identified as *wortheni* the cup has a subpenta-

gonal cross section. In the earlier species of a genus where much material is available, the reference of a given form to one genus or a closely allied one is always more or less arbitrary. In later phylogeny, when the generic characters become well established, there is, of course, little difficulty.

Remarks.—Specimens of *Cribanocrinus* are very rare. This is probably not due to the fact that they were uncommon in the Mississippian seas. Rather, the thin plates of the theca made for an incompetent structure that was rarely preserved. A large percentage of the specimens are more or less crushed and are often imperfect. Specimens are rarely found on weathered surfaces, the thin plates being readily destroyed.

Species referred to the genus.—

Cribanocrinus benedicti (Miller), n. comb.

Rhodocrinus benedicti Miller, 1892, p. 15, pl. 2, figs. 18–20: "Keokuk Group, Harrison County, Indiana" (Borden); 1894, p. 269, pl. 2, figs. 18–20.—Wachsmuth and Springer, 1897, p. 224.

Cribanocrinus bridgerensis (Miller and Gurley), n. comb.

Rhodocrinus bridgerensis Miller and Gurley, 1897, p. 41, pl. 3, fig. 3: "Burlington or Keokuk Group, Bridger Mountains, Montana" (Madison limestone).

Cribanocrinus coxanus (Worthen), n. comb.

Rhodocrinus coxanus Worthen, 1882, p. 29: "Upper part of the geode bed, one mile below Keokuk" (Keokuk) (The geode bed is placed in the Warsaw by some authors); 1883, p. 305, pl. 28, fig. 7.—Wachsmuth and Springer, 1885, p. 99 (321); 1897, p. 222, pl. 13, figs. 6, 7.

Cribanocrinus parvus (Miller), n. comb.

Rhodocrinus parvus Miller, 1891, p. 39, pl. 5, figs. 8, 9: "Keokuk group, Booneville, Cooper County, Missouri" (at present considered Warsaw).—Wachsmuth and Springer, 1897, p. 229.

Cribanocrinus punctatus (Weller), n. comb.

Rhodocrinus punctatus Weller, 1909, p. 282, pl. 11, figs. 15, 16: Fern Glen formation, Jefferson County, Missouri.

Cribanocrinus urceolatus (Wachsmuth and Springer), n. comb.

Rhodocrinus wortheni Hall, var. *urceolatus* Wachsmuth and Springer, 1897, p. 221, pl. 12, figs. 8a, b: "Age of the Lower Burlington limestone, Lake Valley, New Mexico" (Lake Valley limestone).

Cribanocrinus wachsmuthi (Hall), n. comb.

Rhodocrinus wachsmuthi Hall, 1861, p. 18: No horizon or locality given (Lower Burlington, Burlington, Iowa).—Wachsmuth and Springer, 1881, p. 213 (387); 1897, p. 222, pl. 13, figs. 5b–d (not fig. 5a = *C. wortheni*), pl. 15, fig. 7.

Cribanocrinus watersianus (Wachsmuth and Springer), n. comb.

Rhodocrinus watersianus Wachsmuth and Springer, 1889, p. 184, pl. 17, fig. 16: Kinderhook, Le Grand, Iowa (Hampton formation).—Miller, 1889, p. 278, text fig. 421.—Wachsmuth and Springer, 1890, p. 184, pl. 17, fig. 16; 1897, p. 221, pl. 12, fig. 9.—Laudon and Beane, 1937, p. 241, pl. 15, fig. 1.

Cribanocrinus whitei (Hall), n. comb.

Rhodocrinus whitei Hall, 1861a, p. 9: "In sandstone of Chemung group at base of Burlington limestone, Burlington, Iowa" (Lower Burlington); 1861b, p. 325; 1872, pl. 6, figs. 19–21.—Wachsmuth and Springer, 1881, p. 213 (387); 1897, p. 223, pl. 13, figs. 1a–c; pl. 15, figs. 6a, b.

Cribanocrinus wortheni (Hall), n. comb.

Rhodocrinus wortheni Hall, 1858, p. 556, pl. 9, figs. 8a–c: Burlington limestone, Burlington, Iowa (Lower Burlington).—Wachsmuth and Springer, 1881, p. 213 (387); 1897, pl. 11, fig. 6; pl. 12, figs. 7a–c; pl. 13, fig. 5a (as *Rhodocrinus wachsmuthi*).

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BOTANY.—*The Alaskan species of* Puccinellia.[1] JASON R. SWALLEN, Bureau of Plant Industry, Soils, and Agricultural Engineering.

Several years ago, Dr. Eric Hultén, Botaniska Museet, Lund University, Sweden, sent a large number of specimens of *Puccinellia* from Alaska for study and identification. Most of them were collected by Dr. Hultén on rather extensive trips in Alaska and Yukon. The report on this collection was to have formed the basis for the treatment of *Puccinellia* in Dr. Hultén's *Flora of Alaska*, but it was not received until after the second part containing the grasses had gone to press. Since the author's treatment differs considerably from that in Dr. Hultén's flora this account was prepared for publication.

This study is based on the specimens sent by Dr. Hultén, those in the U.S. National Herbarium, and those in the herbarium of the U.S. National Arboretum. Dr. J. P. Anderson, who has made extensive botanical collections in Alaska over a period of years, also sent all his specimens of *Puccinellia* to the author for examination. The assistance given the author by Dr. Hultén and Dr. Anderson is gratefully acknowledged.

[1] Received October 12, 1943.

Puccinellia is one of the circumpolar genera of grasses well represented in North America, especially in Alaska. The species furnish a considerable amount of forage, being leafy, densely tufted grasses. The genus is taxonomically a difficult one, the species being variable and closely allied. Many species have been proposed, but the genus as a whole has not been intensively studied, and the nomenclature is much involved. Some species are common to America and Eurasia, and in the preparation of this paper those of the circumpolar regions have been studied so far as possible.

Puccinellia Parl. Fl. Ital. 1: 366. 1848.

Atropis Rupr. in Griseb. in Ledeb. Fl. Ross. 4: 388. 1853.

Spikelets several-flowered, usually terete or slightly flattened; glumes rather firm, often scarious at the tip, 1- to 3-nerved; lemmas usually firm, rounded on the back, usually scarious and often erose at the tip, 5-nerved, the nerves parallel, usually indistinct. Low smooth cespitose annuals or perennials with narrow to open panicles.

Puccinellia differs from *Poa* chiefly in the rounded lemmas with usually indistinct parallel nerves. The species are mostly found on seashores, in brackish marshes or meadows near the coast, or in alkaline soils in the interior. They range from the Arctic regions of both hemispheres to the middle Western States in America, with a few species in southern South America; to the British Isles and the north coast of the Mediterranean, and to central China and Japan in the Old World. One species is found in Africa and a few in Australia and New Zealand.

KEY TO ALASKAN SPECIES

Anthers 1.8 to 2 mm long; plants low, frequently with widely spreading stolons. 1. *P. phryganodes*

Anthers not more than 1.5 mm long; plants not stoloniferous.

Panicle branches distinctly scabrous.

Anthers 0.3 to 0.5 mm long; lemmas mostly 1.6 to 1.8 mm long; panicle branches very slender, distinctly reflexed at maturity... ..... 2. *P. hauptiana*

Anthers 0.7 mm long or more; lemmas 2 to 4 mm long; panicle branches, if reflexed, relatively stout.

Lemmas 3 to 4 mm long; anthers 1.3 to 1.5 mm long; panicle branches usually narrowly ascending, stout, 10 to 20 cm long..... 3. *P. grandis*

Lemmas 2 to 2.5 mm, rarely 3 mm, long; anthers not more than 1 mm long; panicle branches ascending to reflexed, slender, rarely more than 5 cm long, not stiff..... 4. *P. borealis*

Panicle branches glabrous or (in *P. nutkaensis*) only very sparsely scabrous.

Lemmas 3.5 to 4 mm long; anthers mostly 1.3 to 1.5 mm long.

Panicle branches ascending, elongate. Culms 25 to 40 cm tall; spikelets 5- to 7-flowered, 8 to 10 mm long, the florets spreading..... 5. *P. glabra*

Panicle branches stiffly spreading or reflexed.

Spikelets 2- to 3-flowered, 5 to 7 mm long; lemmas 3.5 to 4 mm long, obtuse; culms densely tufted, erect, 45 to 60 cm tall..... 6. *P. triflora*

Spikelets 5- to 7-flowered, 6 to 8 mm long; lemmas not more than 3.5 mm long, acute or subobtuse, sometimes irregularly toothed; culms 15 to 30 cm tall, erect from a rather long decumbent base..... 7. *P. andersoni*

Lemmas not more than 3 mm long, or if so, the panicle branches appressed; anthers mostly less than 1 mm long.

Lemmas thin (see also *P. kamtschatica*), strongly nerved; anthers 0.3 to 0.6 mm long.

Lemmas 3 to 3.3 mm long; anthers of lowest floret 0.3 to 0.4 mm long; culms as much as 30 cm tall. 8. *P. alaskana*

Lemmas 2 to 2.5 mm long; anthers of lowest floret 0.5 to 0.6 mm long; culms usually less than 10 cm tall.... ..... 9. *P. paupercula*

Lemmas firm (thin in *P. kamtschatica* but the nerves not prominent), the nerves obscure (except the lateral nerves at the base in *P. pumila*); anthers mostly 0.8 to 1 mm long.

Palea longer than the lemma; plants soft with slender culms 15 to 25 cm tall; panicle branches ascending or, at maturity, spreading or reflexed. Lemmas thin, shining, obtuse..... ..... 13. *P. kamtschatica*

Palea equaling the lemma or shorter; plants relatively hard, the culms densely tufted or coarse; panicle branches appressed or stiffly spreading, usually stout.

Panicle branches stout, stiffly spreading or reflexed, naked in lower half. Culms stout, erect from a decumbent base; blades erect, flat, 2 to 2.5 mm wide; lower panicle branches in whorls, long and short ones intermixed, glabrous or obscurely scabrous..... ..... 10. *P. hultenі*

Culms relatively slender, densely tufted, erect or ascending, but the base not decumbent; blades spreading, usually convolute; panicle branches solitary or in pairs with no short ones intermixed, glabrous, with a characteristic pearly lustre. Pedicels swollen below the spikelets..... .....11. *P. pumila*

Panicle branches slender, usually closely appressed, sparsely hispid-scabrous.....12. *P. nutkaensis*

1. **Puccinellia phryganodes** (Trin.) Scribn. & Merr. Contr. U. S. Nat. Herb. **13**: 78. 1910

Poa phryganodes Trin. Mém. Acad. St. Pétersb. VI. Math. Phys. Nat. **1**: 389. 1830.

Perennial; culms 5 to 15 cm tall, erect or ascending from slender rhizomes, frequently with widely spreading stolons; culm sheaths overlapping, those on the stolons usually much shorter than the internodes; ligule 0.5 to 1 mm long, truncate, decurrent; blades soft, lax, mostly involute, 2 to 8 cm, usually less than 5 cm, long; panicles 2 to 2.5 cm long, few-flowered, the short glabrous branches appressed, naked below; spikelets 3- to 5-flowered, 5 to 7 mm long; glumes firm, obtuse, the first elliptic, 1.8 to 2 mm long, 1 nerved, the second elliptic to obovate, 2.5 to 3 mm long; lemmas firm, obtuse, elliptic, glabrous, the lowest 3.5 to 3.8 mm long; palea as long as the lemma, subacute, the keels glabrous; anthers 1.8 to 2 mm long.

Type locality: Kotzebue Sound, Alaska.

Seashores, mud flats, and brackish marshes, Pribilof Islands, Alaska, and Greenland.

SEWARD PENINSULA: Port Clarence, *Walpole* 1633, 1718. NORTON SOUND: St. Michael, *Hitchcock* 4714. PRIBILOF ISLANDS: St. Paul, *Johnston*, June 8 and July 4, 1923 (H), *Hultén* 7330; *J. M. Macoun Geol. Surv. Can.* 16233. ALASKA PENINSULA: Port Moller, *Murie* 2150. SOUTHEASTERN ALASKA: Glacier Bay, *Cooper* 130.

2. **Puccinellia hauptiana** (Krecz.) Kitagawa, Rep. Inst. Sci. Res. Manchukuo **1**: 255. 1937

Atropis hauptiana Krecz. in Kom. Fl. U.R.S.S. **2**: 485, 763, *pl. 36, f. 21*. 1934. *Poa hauptiana* Trin. ex Kom. Fl. U.R.S.S. **2**: 485, 763. 1934, as synonym.

Perennial; culms slender, erect to prostrate, sometimes forming mats, 10 to 40 cm long; sheaths mostly longer than the internodes; ligule 1.5 to 2.5 mm long, obtuse, decurrent; blades 3 to 8 cm long, not more than 1.5 mm wide, flat or loosely involute, especially those on the innovations, the margins more or less scabrous; panicles 3.5 to 15 cm long, the slender scabrous, somewhat flexuous, spreading to reflexed branches mostly in rather distant pairs, naked in the lower third or half, the lowest as much as 7 cm long; spikelets 3- to 5-flowered, 3 to 4 mm long, appressed; glumes acute or subobtuse, the first 1 to 1.5 mm long, 1-nerved, the second 1.2 to 2 mm long, 3-nerved; lemma of lowest floret 1.6 to 2 mm long, obtuse, tinged with bronze or purple, glabrous or very sparsely pubescent on the callus; anthers 0.3 to 0.5 mm long.

Type locality: Siberia.

Wet ground and river banks, Siberia; Alaska, Yukon, and Alberta.

ALASKA: Rampart, *Hitchcock* 4460; Circle City, *Hitchcock* 4437, *J. P. Anderson* 2543; Tanana, *Hitchcock* 4641; Fairbanks, *Hitchcock* 4576, 4617; Copper Center, *Heideman* 2, *Went* 207(H); Gulkana, *J. P. Anderson* 2734; Chitina, *J. P. Anderson* 2028. YUKON: Dawson, *Hitchcock* 4323, 4352. ALBERTA: Banff, *McCalla* 2324.

3. **Puccinellia grandis** Swallen, sp. nov.

Perennis; culmi 50–90 cm alti, dense caespitosi, erecti vel geniculati; vaginae glabrae, inferiores internodiis longiores, superiores internodiis breviores; ligula 2–3 mm longa, obtusa, membranacea; laminae firmae, elongatae, 2–3.5 mm latae, eae innovationum molles, angustiores; paniculae 10–20 cm longae, ramis appressis vel denique patentibus, ad apicem scabris, basi nudis; spiculae 8–15 mm longae, 5–12-florae, appressae; gluma prima 2–3 mm longa, obtusa vel subacuta; gluma secunda 3–3.5 mm longa, obtusa, minute dentata; lemmata 3–4 mm longa, obtusa vel subacuta, obscure nervosa, basi sparse pilosa; palea lemma aequans, carinis obscure ciliatis; antherae 1.3–1.5 mm longae.

Perennial; culms 50 to 90 cm tall, densely tufted, erect or geniculate at the lower nodes; sheaths glabrous, the lower longer, the upper shorter than the internodes; ligule membrana-

ceous, obtuse, 2 to 3 mm long; blades firm, flat or drying involute, elongate, mostly 2 to 3.5 mm wide, those of the innovations often soft and fine; panicles 10 to 20 cm long, pyramidal, the scabrous branches at first appressed but often finally stiffly spreading, usually naked at the base; spikelets 8 to 15 mm long, 5- to 12-flowered, appressed, rather prominently tinged with purple; first glume 2 to 3 mm long, 1-nerved, obtuse or sometimes subacute; second glume 3 to 3.5 mm long, 3-nerved, broader than the first, obtuse, often minutely toothed; lemmas 3 to 4 mm long, rather abruptly narrowed to an obtuse or subacute apex, sparsely pilose at the base, the nerves rather obscure; palea as long as the lemma, obscurely ciliate on the keels; anthers mostly 1.3 to 1.5 mm, rarely as much as 2 mm long.

Type in the U. S. National Herbarium, no. 948937, collected on high sea beaches at Seattle, Wash., June 1890, by C. V. Piper (no. 1451).

Salt marshes and sandy or rocky seashores, Alaska to central California.

Specimens of this species have previously been referred to *Puccinellia nutkaensis*, which is much smaller, the culms mostly 15 to 30 cm tall, with closely appressed, obscurely scabrous branches, the lemmas not more than 3 mm long the anthers mostly only 0.8 to 1 mm long.

ALASKA: Skagway, *Hitchcock* 4186, 4197, 4203; Juneau, *Hitchcock* 4068, 4077; Aurora, *Piper* 4699; Glacier Bay, *Cooper* 106. YUKON: Whitehorse, *Hitchcock* 4289. BRITISH COLUMBIA: Cadbow Bay, *Macoun* 66; Crescent, *Henry* 7; Vancouver Island, *Hitchcock* 4887, *Macoun* 245, *Geol. Surv. Can.* 81003, 91951. WASHINGTON: Seattle, *Piper* 1451; Olympic, *Hitchcock* 23448. OREGON: Gearhart to Tillamook Head, *Chase* 4923; near Gearhart, *Shear & Scribner* 1718. CALIFORNIA: Eureka, *Hitchcock* 13085, *Tracy* 3742, 4820; Samoa, *Tracy* 3147; Point Reyes Peninsula, *Burtt-Davy* 6749.

4. **Puccinellia borealis** Swallen, sp. nov.

Perennis; culmi densi caespitosi, 25–35 cm alti, erecti, basi decumbentes; vaginae internodiis paulo longiores, glabrae, inferiores molles rufo-fuscae; ligula 2 mm longa, obtusa vel truncata, hyalina; laminae 4–8 cm longae, 1–2 mm latae, planae, infra glabrae, supra scabrae, marginibus scabris; paniculae 10–14 cm longae, ramis gracilibus scabris adscendentibus vel reflexis, inferioribus 4–5 cm longis in dimidio inferiore nudis; spiculae 4–6-florae, 4–5 mm longae, appressae, breviter pedicellatae; gluma prima 1–1.5 mm longa, acuta; gluma secunda 1.5–2 mm longa, obovata, obtusa; lemmata 2–2.3 mm longa, obtusa vel subtruncata, minute eroso-ciliata; palea lemmate paulo brevior et multo angustior, carinis hispido-ciliatis; antherae 0.6–0.7 mm longae.

Perennial; culms densely tufted, 25 to 35 cm tall, erect from a usually decumbent base; sheaths mostly a little longer than the internodes, glabrous, the lowermost soft, reddish brown, loose, papery, becoming more or less fibrous; ligule about 2 mm long, obtuse or truncate, hyaline; blades 4 to 8 cm long, 1 to 2 mm wide, flat, glabrous below, scabrous above and on the margins; panicles 10–14 cm long, the slender scabrous branches ascending to reflexed, in rather distant fascicles of 2 to 4, the lower mostly 4–5 cm long, naked for nearly half their length; spikelets 4- to 6-flowered, 4 to 5 mm long, tinged with purple, short-pediceled, appressed to the branches; first glume 1 to 1.5 mm long, acute; second glume 1.5 to 2 mm long, obovate, obtuse; lemmas 2 to 2.3 mm long, obtuse or subtruncate, minutely erose-ciliate; palea a little shorter than the lemma, bifid at the apex, about 0.5 mm wide between the hispid-ciliate keels, much narrower than the broad lemma; anthers 0.6 to 0.7 mm long.

Type in the U. S. National Herbarium, no. 379136, collected on tundra bank, Teller Reindeer Station, near Port Clarence, Alaska, September 7, 1901, by F. A. Walpole (no. 2015).

Seacoast and moist ground, mostly along rivers, Alaska and Yukon.

SEWARD PENINSULA: Deering, *J. P. Anderson* 4788; Kotzebue, *J. P. Anderson* 4670; Port Clarence, *Walpole* 2015; Nome, *Hitchcock* 4815, *J. P. Anderson* 4991. NORTON SOUND: St. Michael, *Hitchcock* 4700. YUKON VALLEY: Fort Yukon, *Bates* in 1889; Tanana, *Henderson* 14988. TANANA VALLEY: Fairbanks, *Hitchcock* 4594, *J. P. Anderson* 1444. YUKON: Dawson, *Hitchcock* 4358.

These specimens have been referred to *P. distans* (L.) Parl., but they are very different in appearance from typical European material. The Alaskan plants are perennial, while the typical European species appears to be annual;

the panicle branches are more slender and not so densely flowered, and the lemmas not so conspicuously broad at the summit. J. P. Anderson, who has studied the plants of Alaska for many years, states that the Alaskan species that has been referred to *P. distans* is apparently native, not introduced into America as is *P. distans*.

Puccinellia borealis is closely related to *P. sibirica* Holmb., differing chiefly in the smaller florets. None of the Siberian material examined agrees with the Alaskan specimens cited above; hence, without a specimen of Holmberg's species for comparison, it seems better to propose a new species than to refer these doubtfully to *P. sibirica*.

5. **Puccinellia glabra** Swallen, sp. nov.

Perennis; culmi 25–40 cm alti, erecti vel basi decumbentes, glabri; vaginae glabrae internodiis longiores; ligula obtusa, decurrens, 3–5 mm longa; laminae 5–14 cm longae, 1.5–3 mm latae, planae vel ad apicem involutae, glabrae; paniculae 10–20 cm longae, ramis adscendentibus, glabris, 4–10 cm longis, basi nudis; spiculae 5–7-florae, 8–10 mm longae, appressae; gluma prima 2–3 mm longa, 1-nervia, acuta vel subobtusa; gluma secunda 3–4 mm longa, 3-nervia, obtusa, minute ciliolata; lemmata 3.5–4 mm longa, obtusa, glabra vel basi sparse pilosa, lucida, obscure nervata; paleae in carinis glabrae; antherae 1.3–1.5 mm longae.

Rather densely tufted perennial; culms 25 to 40 cm tall, erect or decumbent at the base, glabrous; sheaths glabrous, longer than the internodes; ligule thin, obtuse, decurrent, 3 to 5 mm long; blades 5 to 14 cm long, 1.5 to 3 mm wide, flat or becoming involute toward the tip, glabrous; panicles mostly 10 to 20 cm long, the glabrous branches ascending, 4 to 10 cm long, naked at the base; spikelets 5- to 7-flowered, 8 to 10 mm long, appressed, the florets somewhat spreading, pale or tinged with purple; first glume 2 to 3 mm long, 1-nerved, acute or subobtuse; second glume 3 to 4 mm long, 3-nerved, obtuse, minutely ciliolate; lemmas 3.5 to 4 mm long, obtuse, glabrous, or with a few hairs at base, rather thin and shining, the nerves obscure; palea a little shorter than the lemma, the keels not ciliate; anthers 1.3 to 1.5 mm long.

Type in the U. S. National Herbarium, no. 749542, collected on flats frequently overflowed by tides, Kasilof ("Kussiloff"), Kenai Peninsula, Alaska, in 1898 by Walter H. Evans (no. 609).

The relationship of *Puccinellia glabra* to the other Alaskan species is obscure. The relatively long ascending panicle branches, the spreading florets, and long lemmas are characteristic.

Tidal flats, Alaska and Kenai Peninsulas and Kodiak Island.

ALASKA PENINSULA: Women's Peninsula, *Church* in 1916. KENAI PENINSULA, Kasilof, *Evans* 609. KODIAK ISLAND, *Piper* 4696.

6. **Puccinellia triflora** Swallen, sp. nov.

Perennis; culmi erecti, dense caespitosi, 45–60 cm alti; vaginae glabrae internodiis paulo longiores; ligula 4–5 mm longa, tenuis, obtusa, decurrens; laminae 4–6 cm longae vel eae innovationum longiores, 1–1.5 mm latae, molles, glabrae, planae vel involutae; paniculae 15–20 cm longae, ramis fasciculatis abrupte patentibus vel reflexis basi nudis; spiculae 5–7 mm longae, 2–3-florae, appressae, purpurascentes; glumae acutae vel subobtusae, prima 1.5–3 mm longa, 1-nervia, secunda 2.5–4 mm longa, 3-nervia; lemmata 3.5–4 mm longa, lata, obtusa, basi sparse pilosa; palea lemma aequans, carinis prominentibus glabris; antherae 1.3–1.5 mm longae.

Erect, densely tufted perennial; culms 45 to 60 cm tall, glabrous; sheaths glabrous, overlapping or a little shorter than the internodes; ligule thin, obtuse, decurrent, 4 to 5 mm long; blades 4 to 6 cm long or those of the innovations longer, 1 to 1.5 mm wide, soft, glabrous, flat or becoming loosely involute; panicles 15 to 20 cm long, the branches glabrous, in rather distant fascicles of 2 to 4, naked at base, stiffly and abruptly spreading or reflexed, the branchlets appressed; spikelets 5 to 7 mm long, 2 or 3-flowered, appressed, deeply tinged with purple; glumes acute or sometimes subobtuse, the first 1.5 to 3 mm long, 1-nerved, the second 2.5 to 4 mm long, 3-nerved; lemmas 3.5 to 4 mm long, broad, obtuse, the nerves evident, sparsely pilose at the base or nearly glabrous; palea as long as the lemma, the keels prominent, glabrous; anthers 1.3 to 1.5 mm long.

Type in the U. S. National Herbarium, no. 948675, collected on flat near creek, at Tyoonok ("Tyoonock"), Cook Inlet, Alaska, by Walter H. Evans in 1897 (no. 480).

Puccinellia triflora is related to *P. glabra*, differing in the taller culms and stiffly spread-

ing or reflexed panicle branches, and in the spikelets only 2- or 3-flowered.

This species was also collected on flats that are overflowed by spring tides at Kasilof ("Kussiloff"), Kenai Peninsula, *Evans* 684.

7. **Puccinellia andersoni** Swallen, sp. nov.

Perennis; culmi densi caespitosi, erecti, basi decumbentes, 15–30 cm alti; vaginae glabrae, internodiis longiores, inferiores tenues, rufofuscae; ligula 2 mm longa, decurrens; laminae planae, 5–11 cm longae, 1–2.5 mm latae, glabrae; paniculae 4–8 cm longae, ramis rigidis, glabris, adscendentibus vel patentibus, 2–4 cm longis, 1–5-spiculatis; spiculae 5–7-florae, 6–8 mm longae; gluma prima 2 mm longa, acuta; gluma secunda 2.5–3 mm longa, latior, acuta vel subobtusa; lemmata 3–3.5 mm longa, acuta, dentata, basi sparse pilosa; palea lemma aequans, carinis prope apicem sparse scabris; antherae 0.8–1 mm longae.

Perennial; culms densely tufted, erect from a decumbent base, 15 to 30 cm tall, with short ones, 5 to 8 cm tall, apparently from the outside of the clump; sheaths glabrous, longer than the internodes, the lower loose, thin, reddish brown, becoming fibrous; ligule thin, decurrent, 2 mm long; blades flat, 5 to 11 cm long, 1 to 2.5 mm wide, glabrous; panicles 4 to 8 cm long, the branches relatively stout, glabrous, stiffly ascending to spreading, 2 to 4 cm long, bearing 1 to 3 or sometimes 5 appressed spikelets; spikelets 5- to 7-flowered, 6 to 8 mm long; first glume 2 mm long, acute, the second 2.5 to 3 mm long, much broader, acute or subobtuse; lemma 3 to 3.5 mm long, usually acute, sometimes irregularly toothed, sparsely pilose at the base and on the lower part of the prominent nerves; palea as long as the lemma, the keels sparsely scabrous near the summit; anthers 0.8 to 1 mm long.

Type in the herbarium of the U. S. National Arboretum, collected in very wet soil, Point Lay, Arctic Alaska, August 5, 1938, by J. P. Anderson (no. 4399a).

This is a rather distinct species and its relationship is not evident. The long decumbent base, short, stiffly spreading panicle branches, and acute, more or less toothed, lemmas are characteristic. Only known from the type collection. Mr. Anderson's no. 4399 consisted of specimens of this species and of *Puccinellia paupercula*. Those of *P. andersoni* have been labeled 4399a, while those of *P. paupercula* have been labeled 4399b.

8. **Puccinellia alaskana** Scribn. & Merr. Contr. U. S. Nat. Herb. 13: 78. 1910

Puccinellia paupercula var. *alaskana* Fern. & Weath. Rhodora 18: 18. 1916.

Perennial; culms in small dense tufts, erect or ascending, 6 to 30 cm tall; sheaths soft, much longer than the internodes; ligule 2 to 3.5 mm long, hyaline, decurrent; blades flat or loosely folded, 2 to 9 cm long, 1 to 2 mm wide; panicles 3 to 9 cm long, the short slender glabrous branches appressed or ascending; spikelets 3- or 4-flowered, 4 to 5 mm long; glumes contorted, strongly nerved, the first 1 to 1.5 mm long, subacute to obtuse, entire, the second 2 to 2.5 mm long, 3-nerved, oblong to obovate, entire or erose; lemma prominently 5-nerved, abruptly narrowed to an irregular subacute tip, densely pubescent at the base, the lowest 3 to 3.3 mm long; palea as long as the lemma, ciliate on the keels; anthers of lowest floret 0.4 to 0.5 mm long.

Differs from *P. paupercula* in its usually larger size, flat broader blades, and its longer more distant lemmas, densely pubescent below (nearly glabrous in *P. paupercula*).

Type locality: St. Paul, Pribilof Islands.

Islands of Bering Sea and Western Alaska. SEWARD PENINSULA: Port Clarence, *Walpole* 1889. NUNIVAK ISLAND: Nash Harbor, *J. P. Anderson* 3864. ST. MATTHEW ISLAND: *Cole* in 1899. PRIBILOF ISLANDS: St. Paul, *Haley* in 1925, *Hultén* 7489, 7498(H), *Johnston*, June 30, 1923(H), *Kincaid*, Aug. 24, 1897, *Macoun*, Aug. 11, 1892, and in *Geol. Surv. Can.* 94198, *Merriam*, Aug. 4, 1891, *Trelease & Saunders* 2960; St. George, *W. H. Palmer* "Aug. 11," *Johnston*, Aug. 5, 1920. ALEUTIAN ISLANDS: Agattu, *Hultén* 6319; Semisopochnoi, *Steenis* 4619(H); Atka, *Eyerdam* 994, *Hultén* 6996, 7017; Amlia, *Eyerdam* 1272, 1273; Carlisle, *Eyerdam* 1387; Umnak, *Hultén* 7086(H); "Ogliuga," *Murie* 2108. SHUMAGIN ISLANDS: Popof, *Kincaid*, July 14, 1899.

9. **Puccinellia paupercula** (Holm) Fern. & Weath. Rhodora 18: 18. 1916

Glyceria paupercula Holm, Repert. Sp. Nov. Fedde 3: 337. 1907.

Perennial; culms very slender in small dense tufts, 5 to 15 cm tall, scarcely exceeding the blades; sheaths crowded, the lowest rather papery becoming shredded in age; ligule 0.5 to 0.8 mm long, usually not decurrent; blades 2 to 4 cm long, 0.5 to 1 mm wide, flat or usually loosely involute, straight or falcate; panicles 1 to 7 cm long, few-flowered, the slender glabrous relatively distant branches appressed or sometimes spreading, naked below; spikelets 3- to 5-flowered, 4 to 8 mm long, the florets not crowded; first glume 1 to 1.5 mm long, 1-nerved, acute to subobtuse; second glume 1.5 to 2 mm long, 3-nerved, subacute to obtuse; lower lemma rather strongly 5-nerved, 2 to 2.5 mm long (rarely to 2.8 mm), elliptic to obovate, erose, glabrous or very sparsely pilose at the base; palea a little shorter than the lemma, the keels glabrous; anthers 0.5 to 0.6 mm long.

Type locality: Mansfield Island, Hudson Bay.

Rocky and sandy shores, Arctic America.

ARCTIC ALASKA: Point Lay, *J. P. Anderson* 4399b; Point Hope, *J. P. Anderson* 4603; Point Martin, *Johansen* 145 (Geol. Surv. Can. 97948). BERING STRAIT: St. Lawrence Island, *Geist*, July–Aug. 1931; "Arakamtchetchene" Island, *Wright* in 1853–56. ALEUTIAN ISLANDS: Agattu, *Hultén* 6320; Unalga, *Steenis* 4658(H).

10. **Puccinellia hulteni** Swallen, sp. nov.

Perennis; culmi rigidi, erecti, basi decumbentes, 35–40 cm alti; vaginae internodiis longiores, glabrae; ligula 2.5–3 mm longa, tenuis, decurrens; laminae 5–11 cm longae, 2–2.5 mm latae, erectae, nervosae, glabrae; paniculae 8–14 cm longae, ramis rigide adscendentibus vel patentibus, glabris vel obscure scabris, inferioribus 5–8 cm longis, in parte superiore floriferis; spiculae 3–4-florae, 5–6 mm longae; gluma prima 1.5–2 mm longa, 1-nervia, acuta vel subacuta; gluma secunda 2–2.5 mm longa, 3-nervia, obtusa vel subacuta; lemmata 2.5–2.8 mm longa, subobtusa, basi obscure pubescentia; palea lemmate brevior, minute dentata, carinis scabris; antherae 0.8 mm longae.

Perennial; culms stiffly erect from a decumbent base 35 to 40 cm tall; sheaths much longer than the internodes, glabrous; ligule hyaline, decurrent, 2.5 to 3 mm long; blades 5 to 11 cm long, 2 to 2.5 mm wide, narrower on the innovations, stiff, erect, strongly nerved, glabrous; panicles 8 to 14 cm long, the glabrous or obscurely scabrous branches stiffly ascending or spreading, the lower 5 to 8 cm long with shorter ones intermixed, loosely few-flowered above the middle; spikelets 3- or 4-flowered, 5 to 6 mm long; first glume 1.5 to 2 mm long, 1-nerved, acute or subacute, the second 2 to 2.5 mm long, broader than the first, 3-nerved, subacute or obtuse; lemma 2.5 to 2.8 mm long, acutish, obscurely pubescent on the strong lateral nerves at the base; palea a little shorter than the lemma, minutely toothed, rather strongly scabrous on the keels, especially toward the summit; anthers 0.8 mm long.

Type in the U. S. National Herbarium, no. 1819613, collected at Port Hobron, Sitkalidak Island, Kodiak, Alaska, August 20, 1931, by W. J. Eyerdam (no. 131).

The stiffly erect culms with erect flat blades and open panicles with stiffly ascending branches of irregular length are characteristic. Probably most closely related to *P. pumila* which is much smaller, with short densely flowered branches and much more obtuse lemmas.

Seashores, Kodiak and neighboring islands, Kenai Peninsula, and southeastern Alaska.

KODIAK: Old Harbor, *Eyerdam* 651; Sitkalidak Island, *Eyerdam* 131. KENAI PENINSULA: Tutka Bay, *Hultén* 7782. SOUTHEASTERN ALASKA: Sitka, *Hultén* 8582.

11. **Puccinellia pumila** (Vasey) Hitchc. Amer. Journ. Bot. **21**: 129. 1934

Glyceria pumila Vasey, Torrey Bot. Club Bull. **15**: 48. 1888.

Atropis kurilensis Takeda, Journ. Linn. Soc. Bot. **42**: 497. 1914.

Puccinellia kurilensis Honda, Journ. Fac. Sci. Univ. Tokyo Sec. III, Bot. **3**: 59. 1930.

Perennial; culms in loose or rather dense tufts, erect or decumbent at the base and geniculate-ascending, 10 to 30 cm tall; sheaths usually much longer than the internodes; ligule 1.5 to 2.3 mm long, hyaline, truncate, decurrent; blades flat, as much as 20 cm long, usually much shorter, 1 to 2.5 mm wide, scaberulous; panicles 2.5 to 15 cm long, the glabrous branches stiffly ascending to reflexed, naked in the lower half, sometimes in depauperate specimens bearing only a single spikelet; spikelets 4- to 6-flowered, 5 to 7 mm long, appressed;

first glume 1.5 to 2.5 mm long, 1-nerved, subacute; second glume 2.5 to 3 mm long, 3-nerved, subacute; lower lemma about 3 mm long, rather abruptly narrowed toward the subacute apex, the nerves usually conspicuous, sparsely pubescent on the callus; palea as long as the lemma, the keels glabrous; anthers of lower floret 0.8 to 1.2 mm long.

The eastern material which has been referred to this species requires further study, at least some of it may represent another species.

Type locality: Vancouver Island.

Brackish marshes and seashores, Alaska to Vancouver Island.

KODIAK: *Griggs*, Aug. 15, 1915, *Piper* 4701. COOK INLET: Halibut Cove, *Coville & Kearney* 2456. PRINCE WILLIAM SOUND: Orca, *Coville & Kearney* 1336. SOUTHEASTERN ALASKA: Sitka, *Hitchcock* 4139½; Skwashianski Bay, *Piper* 4698.

12. **Puccinellia nutkaensis** (Presl) Fern. & Weath. Rhodora **18**: 22. *f. 49–53*. 1916

Poa nutkaensis Presl, Rel. Haenk. **1**: 272. 1830.

Perennial; culms relatively slender in dense tufts, mostly 15 to 30 cm tall, rarely as much as 45 cm, erect or sometimes ascending at the base; sheaths overlapping or the upper occasionally shorter than the internodes; ligule 1 to 2 mm long, obtuse or truncate, decurrent; blades 3 to 13 cm long, 1 to 2 mm wide, soft, flat or folded, glabrous or very sparsely scabrous on the upper surface; panicles 5 to 12 cm long, the few slender glabrous branches appressed, naked toward the base, the lower rarely more than 5 cm long; spikelets 4- to 6-flowered, 7 to 8 mm long; first glume 1.5 to 2 mm long, 1-nerved, subobtuse; second glume 2 to 2.5 mm long, 3-nerved, ovate or broadly elliptic, obscurely ciliolate; lemma of lowest floret 3 mm long, elliptic, glabrous except for a few hairs on the callus and sometimes on the lateral nerves near the base; palea as long as the lemma, sparsely scabrous; anthers 0.8 to 1.2 mm long.

Type locality: "Nootka Sound?"

Beaches and sandy or rocky soil near the coast, Alaska.

This is on the whole a characteristic and uniform species, apparently the commonest of those found in Alaska.

ALEUTIAN ISLANDS: Atka, *Hultén* 6989(H), 7012, *Turner* 1208. SHUMAGIN ISLANDS: Popof, *Hultén* 7742, *Saunders*, July 7–18, 1899, *Trelease & Saunders* 2946. KODIAK ISLAND: *Eyerdam* 497, *Coville & Kearney* 2240, *Trelease & Saunders* 2942, 2945, 2973, *Cole*, July 19, 1899, *Kincaid*, July 20, 1899. ALASKA PENINSULA: Kukak Bay, *Coville & Kearney* 1588; Fox Bay, *Griggs*, July 28, 1913. KENAI PENINSULA, Tutka Bay, *Hultén* 7785 (H). PRINCE WILLIAM SOUND: Hinchinbrook Island, *Norberg*, June 4, 22(H), and 28, July 14, 1936, July 14 and 20, 1937; Knight Island, *Eyerdam* 10; Cordova, *Hitchcock* 4145. YAKUTAT BAY: *Funston* 31, *Trelease & Saunders* 2939. SOUTHEASTERN ALASKA: Skagway, *J. P. Anderson* 1717(H), 1719, *Eastwood* 730, 730A, *Walker* 808; Yes Bay, *Howell* 1718, Lynn Canal, *Krause* 276, 276a(H); Juneau, *J. P. Anderson* 197; Howkan, *Evans* 144; Davidson Glacier, *Cooper* 76; Sitka, *Coville & Kearney* 843, *Evans* 257, *Hitchcock* 4053, *Piper* 4697, *W. G. Wright* 1585, 1593; Chichagof Island, *Norberg* 183, 188, 203; Ketchikan, *J. P. Anderson* 481.

13. **Puccinellia kamtschatica** Holmb. var. **sublaevis** Holmb. Bot. Not. **1927**: 209. 1927

Perennial; culms rather densely tufted, erect or somewhat decumbent at the base, 12 to 25 cm high; sheaths smooth, all longer than the internodes; ligule membranaceous, about 2 mm long; blades smooth, rather soft, flat or drying involute, not more than 2 mm wide; panicles 4 to 10 cm long, the branches rather narrowly ascending, or eventually spreading, sparsely scabrous, mostly spikelet-bearing in the upper half; spikelets 3- or 4-flowered, 3 to 4 mm long; first glume acute, about half as long as the first lemma; second glume much broader, obtuse, the tip hyaline; lemmas 2 mm long, obtuse, glabrous; anthers 0.6 to 0.8 mm long.

Type locality: Schtschapina, Kamchatka.

Cold wet soil, Kamschatka and Alaska.

SHUMAGIN ISLANDS: Popof, *Hultén* 7747. SOUTHEASTERN ALASKA: Glacier Bay, *Cooper* 165; Holkham Bay, *Cooper* 369.

BOTANY.—*Five new species of* Dryopteris *from Peru.*[1]

WILLIAM R. MAXON, United States National Museum.

The new species of *Dryopteris* herewith described are part of the extensive collections made by Dr. J. Francis Macbride in Peru under the auspices of Field Museum of Natural History in 1922 and 1923, the ferns of which were entrusted to the writer for study. The series is a valuable one; but like most large Andean fern collections obtained recently it includes a great deal of critical material which it is impossible to identify without recourse to type specimens in European herbaria or, in the case of several especially difficult genera such as *Elaphoglossum*, without monographic studies. Anything like a complete report is thus not feasible at present. Owing mainly to Christensen's "Revision" and later monographs the situation with respect to *Dryopteris* is sufficiently clear, however, to justify proposing the present new species, all belonging to the subgenus *Lastrea*.

Dryopteris assurgens Maxon, sp. nov.

§*Lastrea*. Rhizoma epigaeum, oblique adscendens vel rampans, 15 cm et ultra longum, gracile (3–4 mm diam.), brunneum, laeve, leviter sulcatum, radices crassas perpaucas emittens, subnudum, parcissime paleaceum, paleis adpressis, interdum propinquis sed non imbricatis, 3–4 mm longis, e basi cordata anguste ovatis vel oblongo-ovatis, 1–1.5 mm latis, acuminatis, glabris, castaneis, lucidis et reticulatis, marginibus scariosis pallidioribus. Folia ut videtur ca. 6, 60–70 cm longa, stipitibus oblique affixis, decurrentibus, non imbricatis, 20–25 cm longis, 2 mm diam., e basi brunnea stramineis, epaleaceis, lucidis, glabris; laminae anguste lanceolatae, 45–55 cm longae, medio 12–16 cm latae, apice acuminatae, pinnato-pinnatifidae, basi abrupte angustatae, rhachi straminea, glabra; pinnae ca. 25-jugae, pleraeque oppositae et patentes, infimae (2 vel 3 paria) auriculiformes, deflexae, 5–15 mm longae; pinnae mediales maximae 6–8.5 cm longae, medio 12–16 mm latae, basi usque ad 18 mm latae, linearilanceolatae, attenuatae, subpinnatisectae, membranaceo-herbaceae, glabrae, costis supra strigosis et segmentis ciliolatis exceptis; segmenta ca. 20-juga, pleraque 5–9 mm longa, 2–2.5 mm lata, anguste oblonga, acutiuscula, patentia, subfalcata, fere plana, oblique ciliolata, basi angustissime conjuncta, ala costae latere utroque ca. 0.5 mm lata; segmenta basalia superiora maxima, usque ad 1 cm longa et 3.5 mm lata, saepe crenata et rhachin incumbentia; venae 6–8-jugae, obliquae, manifestae sed non prominulae, simplices vel (segmentis basalibus superioribus) furcatae; sori 6–8-jugi, exacte mediales, mediocres, non-indusiati; sporangia numerosa, glabra.

Type in the herbarium of Field Museum of Natural History, no. 1136977, collected near Playapampa, Peru, altitude about 2700 meters, shaded situation in sphagnum, June 16–24, 1926, by J. Francis Macbride (no. 4517a). The description is drawn partly also from an excellent detached frond mounted on the type sheet of *Dryopteris furva*, the two species, though utterly unlike, having somehow been combined under a single number now divided as no. 4517 and no. 4517a.

In its very long, slender, epigaeous rhizome and few, very oblique fronds with decurrent non-imbricate stipe-bases *Dryopteris assurgens* is similar to *D. longicaulis* (Baker) C. Chr.[2] and *D. cornuta* Maxon,[3] and to these species only. It possibly belongs to the group of *D. sancta* (L.) Kuntze.

Dryopteris furva Maxon, sp. nov.

§*Lastrea*. Rhizoma (pars) curvato-adscendens, 5 cm longum, ca. 8 mm diam., apice laxe squamosum, paleis 3–4 mm longis, ovato-deltoideis, acutis, integris, concavis, brunneis, minute pubescentibus, subopacis. Folia ut videtur 10–12, fasciculata, ca. 55 cm longa, stipitibus ca. 15 cm longis, 1.5 mm diam., brunneis, lucidis, minute pubescentibus, demum glabratis; laminae anguste lineares, 40 cm longae, maxime 4–4.5 cm latae, apice attenuatae, basin versus longe et gradatim angustatae, pinnato-pinnatifidae, rhachi stipiti simili sed graciliore, parce et minute pubescente; pinnae

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 20, 1943.

[2] Illustrated in Hook. Icon. Pl. 17: *pl. 1658*. 1886.

[3] Journ. Washington Acad. Sci. 19: 245. *fig. 1*. 1929.

infra apicem pinnatifidum ca. 30-jugae, sessiles, pleraeque oppositae, inferiores ca. 8-jugae reductae, quarum 4 vel 5 paria infima 1–2 mm solum longa, inter se ca. 3 cm distantia; pinnae mediales maximae 2–3 cm longae, 8–11 mm latae, oblongae vel anguste deltoideo-oblongae, patentes, falcatae, pinnatifidae, apice subacuto leviter lobatae, aerophoris basi pinnarum ellipticis, planis, humilibus, vix perspicuis; segmenta ca. 10-juga, rigide herbacea vel subcoriacea, oblonga, integra, concavo-revoluta, costae latere utroque ala 1–1.5 mm conjuncta, venis 4–6-jugis, simplicibus, obliquis, utrinque prominentibus; costae costulaeque et venae subtus substrigillosae, supra (cum parenchymate) parce strigillosae; sori numerosi, mediales, mediocres; sporangia glabra; indusia firme et rigide affixa, persistentia, pallida, reniformia, copiose pubescentia et ciliata, pilis brevibus, rigidis, simplicibus.

Type in the herbarium of Field Museum of Natural History, no. 535604, collected near Playapampa, Peru, altitude about 2700 meters, shaded situation in sphagnum, June 16–24, 1926, by J. Francis Macbride (no. 4517).

Although the present species runs to the West Indian *D. scalpturoides* (Fée) C. Chr. in Christensen's key, it obviously needs no comparison with that, nor is it closely related to any species previously described. In general appearance, and especially in their polished brown stipe and rachis, individual fronds resemble a narrow form of *D. pavoniana* (Kl.) C. Chr., but that species is larger and, though similar in pubescence, differs greatly in its very slender, wide-creeping, branched rhizome, its abruptly reduced blades (with only one or two pairs of auriculiform or glandulform basal pinnae), its depressed venation and non-indusiate sori, and the presence of conspicuous tuberculiform aerophores at the base of the larger pinnae.

Dryopteris macbridei C. Chr. & Maxon, sp. nov.

§*Lastrea*. Rhizoma suberectum, crassum, fortasse 5–8 cm longum, ca. 1.5 cm diam., conspicue paleaceum, paleis numerosis, imbricatis vel apice fastigiatis, e basi anguste retusa ca. 1 mm lata subulato-attenuatis, ca. 1 cm longis, brunneo-castaneis, subflexuosis, glabris, integris vel subintegris. Folia ut videtur 8–10, suberecta, 40–60 cm longa, stipitibus 5–10 cm longis, 1.5–2.5 mm diam., basi laxe et decidue paleaceis, dense hirtellis, pilis sordide ochroleucis, subrectis, 1–1.5 mm longis; laminae lanceolato-ellipticae, 35–55 cm longae, medio 7–12 cm latae, apice acuminatae, basin versus abrupte reductae, pinnato-pinnatifidae, rhachi valida stipiti simili; pinnae majores 25–30-jugae, sessiles, pleraeque alternae et patentes, inferiores reductae ca. 8-jugae, quarum ca. 5 paria infima minute glanduliformia, inter se distantia; pinnae mediales maximae 5–6 cm longae, medio 8–10 mm latae, basi 10–13 mm latae, lineari-lanceolatae, subpinnatisectae, apice attenuato oblique lobatae, spongioso-herbaceae, ubique conspicue hirtellae; segmenta patentia, ca. 25-juga, pleraque 4–6 mm longa, ca. 1.5 mm lata, anguste oblonga, acutiuscula, recta, ciliata, marginibus late et valde revolutis, basi anguste conjuncta, ala costae latere utroque ca. 0.5 mm lata; venae 7–9-jugae, simplices; sori 6–8-jugae, paulum supramediales, magni, conferti, a marginibus late revolutis partim occulti, sporangiis non setosis; indusia mediocria, persistentia, conspicue setosa, pilis rigidis ochroleucis.

Type in U. S. National Herbarium, no. 1193334, collected near Yanano, Peru, altitude about 1800 meters, at edge of thicket, June 29, 1923, by J. Francis Macbride (no. 3828); isotype in herb. Field Museum of Natural History, no. 534890.

In general appearance *D. macbridei* resembles *D. utañagensis* Hieron., of Colombia and Ecuador, of which (besides five specimens from Colombia) there is at hand an excellent photograph of the incomplete type specimen from Ecuador (*Stübel* 809); also it was regarded by Christensen as probably most closely related to that species. Among other characters *D. utañagensis* differs sharply, however, in its falcate segments, which have 10 to 12 pairs of veins, margins narrowly and closely revolute, pubescence substrigose, sori medial and non-indusiate, and under surface mostly exposed. In strong contrast are the very deeply and widely revolute margins in *D. macbridei*, which nearly meet over the costule, crowding together the conspicuously setose-indusiate sori and wholly obscuring the leaf tissue. The subhirsute or hirtellous condition is nearly uniform throughout.

Dryopteris densa Maxon, sp. nov.

§*Lastrea*. Rhizoma ut fragmento parvo vide-

tur erectum, magnum. Folia valida, certe suberecta et caespitosa, saltem 1–1.2 m longa, stipitibus 25–30 cm longis, 6–8 mm diam., alte sulcatis, sordide ochraceo-brunneis, tenuiter albido-pilosulis, et praecipue ad basin paleis usque ad 1 cm longis e basi ovata longissime attenuatis ochraceo-brunneis flaccidis tenuibus instructis, demum denudatis; laminae anguste ovatae, 80–90 cm et ultra longae, 30–40 cm latae, apice acuminatae, pinnato-pinnatifidae, basi abrupte angustatae, rhachi albido-pilosula, paleis caducis angustis pallidis paucis praedita; pinnae ca. 30-jugae, pleraeque leviter adscendentes vel subrecte patentes, inferiores (4 vel 5 paria) reductae, suboppositae, deflexae, infimae fere alternae, ca. 1 cm longae; pinnae mediales maximae 15–23 cm longae, basi et medio 2.5–3.5 cm latae, lineares, apicem serratum versus longe attenuatae, pinnatifidae, spongioso-herbaceae, basi aerophoro ochraceo verruciformi humili instructae, costis subtus paleis caducis linearibus laxis pallidis paucis praeditis, utrinque cum costulis et pagina superiore laxe pilosulis; segmenta ca. 30-juga, subrecte patentia, leviter falcata, pleraque 12–18 mm longa, medio ca. 4 mm lata, deltoideo-oblonga vel e basi dilatata lineari-oblonga, acutiuscula vel false acuta, marginibus anguste sed firme revolutis, basi late conjuncta, ala costae latere utroque 1.5–2 mm lata; venae 9–12-jugae, simplices, sub angulo 45° egredientes, immersae; sori 8–11-jugi, mediales, rotundi, magni, creberrimi, sporangiis numerosissimis segmenti paginam inferiorem omnino obtegentibus; indusia perspicua, suborbicularia, papyracea, fere plana, albida, albido-pilosula, receptaculo elevato firme affixa, persistentia.

Type in the herbarium of Field Museum of Natural History, nos. 535250 and 535251, collected at Huacachi, a station near Muña, Peru, altitude about 1950 meters, May 20–June 1, 1923, by J. Francis Macbride (no. 4175); isotype in the U. S. National Herbarium, no. 1193387.

This is a truly remarkable species. The National Herbarium specimen was sent to Christensen, who annotated it (1927) as follows: "Totally different from all species described. Should be described after more complete specimens, if at hand." No new collections have since been received. Nevertheless the necessary additional data are provided by the Field Museum specimens, which include the lower half of a blade, a nearly complete stipe, and a fragment of the rhizome.

Dryopteris densa is a sturdy plant and probably grows to a height of 1.5 meters or more. The species name refers to the superabundant sporangia of the closely crowded sori, completely covering the segments beneath from costule to tightly revolute margin. Except for the presence of the conspicuous but slightly folded, elevated, persistent, whitish indusia in a double regular row, the sori at maturity have lost their distinctness. They are not at all concealed by the margins. These features, coupled with the weakly pilosulous covering of the upper surface of the segments, are noteworthy and, in combination, distinctive. As to habitat the collector's note reads, "Large clump, in thicket."

Dryopteris dumetorum Maxon, sp. nov.

§*Lastrea.* Rhizoma ut videtur late repens (pars praesens ca. 10 cm longa), gracile, 3–5 mm diam., brunneum, laeve, crasse radicosum, praecipue apice paleaceum, paleis subulato-attenuatis, 4–7 mm longis, basi truncata ca. 1 mm latis, opace brunneis, albido-pubescentibus, integris. Folia 3 vel 4, disticha, 45–85 cm longa, stipitibus 10–20 cm longis, 2–3.5 mm diam., sulcatis, e basi brunnescente arcuata olivaceis vel subferrugineis, hinc inde laxe paleaceis, hirtellis, pilis valde inaequalibus, usque ad 1.5 mm longis; laminae anguste lanceolatae, 25–65 cm longae, medio 11–20 cm latae, apice acuminatae, pinnato-pinnatifidae, basi subgradatim vel abrupte reductae, rhachi 1–2 mm diam., notis omnibus stipiti simili; pinnae 20–25-jugae, pleraeque alternae, patentes, inferiores (2–4 paria) reductae, infimae minutissimae, remotae; pinnae maximae 5–10 cm longae, 12–18 mm latae, lanceolatae vel linearilanceolatae, basi raro paulum angustatae, apice acuminatae, pinnatifidae, herbaceae, basi aerophoro brunneo rotundo duro instructae, costis supra subdense subtus parce hirtellis, etiam subtus paleis brunneis lineari-lanceolatis parvis (1.5–2.5 mm longis, 0.2–0.4 mm latis) paucis praeditis; segmenta 18–23-juga, pleraque 5–8 mm longa, basi 3–4 mm lata, oblonga, false acuta, subfalcata, subrecte patentia, marginibus anguste revolutis, basi late conjuncta, ala costae latere utroque 1.5–2 mm lata; venae 7–10-jugae, obliquae, prominulae, simplices, cum costulis utrinque oblique hirtellae; sori

6–9-jugi, mediales, rotundati, mediocres; sporangia glabra; indusia ex pilis pluribus albidis rigidis suberectis longis constata.

Type in the herbarium of Field Museum of Natural History, no. 518164, collected near Mito, Peru, altitude about 2700 meters, in partly sunny places of thickets, July 8–22, 1922, by J. Francis Macbride and William Featherstone (no. 1667); isotype (an immature plant) in U. S. National Herbarium, no. 1121953.

Dryopteris dumetorum belongs to the general group of *D. rudis* (Kunze) C. Chr., though it is not closely related to that species itself. Apparently it has no very near relatives; but the boundaries of this group as defined by Christensen are not very clear, and its dozen or so species need to be redescribed and compared on the basis of better material, the original specimen in several instances having lacked, for example, the rhizome.

ZOOLOGY.—*Geographical distribution of the nemerteans of the Pacific coast of North America, with descriptions of two new species.*[1] WESLEY R. COE, Scripps Institution of Oceanography. (Communicated by WALDO L. SCHMITT.)

An examination of the nemerteans in the collections of the United States National Museum revealed two species from the Pacific coast of North America believed to be new to science, in addition to many others from new localities. Most of them were dredged on the cruises of the U.S. Bureau of Fisheries steamer *Albatross* off the coasts of California, Washington, and Alaska and in the seas adjacent to the Japanese islands. These records are included in the following list, which shows the habitat and geographical distribution of each of the Pacific coast species so far as known at the present time. This list will supplement the data contained in the "Revision of the nemertean fauna of the Pacific coasts of North, Central and northern South America" (Coe, 1940). The total number of species now known from the Pacific coast of North America is increased to 99. Of these, 65 have been found only on the Pacific coast of North America, including Bering Sea and the adjacent Arctic coast of Alaska; 16 occur also on the coasts of Japan; 11 on the Atlantic coast of North America; 14 in European waters; 5 on South African shores; and 7 on the Pacific coast of South America.

Order PALEONEMERTEA
Family Tubulanidae

1. *Tubulanus albocinctus* Coe. Among red algae at depths of 100 to 200 meters; off coast of southern California.

2. *T. capistratus* Coe. Intertidal zone; coast of Alaska to Monterey Bay, Calif.; Japan. One specimen nearly a meter in length was collected by the *Albatross* in 1906 near Hakodate, Japan.

3. *T. cingulatus* Coe. Yes Bay, Behm Canal, Alaska, 290–400 meters; intertidal zone; Monterey Bay, Calif.

4. *T. frenatus* Coe. Intertidal zone; southern California.

5. *T. nothus* Bürger. Intertidal zone to 40 meters; coast of Alaska; South Africa; Mediterranean. The Alaska records are from preserved specimens only, and there remains the possibility they may actually have represented *T. annulatus* (Montagu), which is similar in markings and which is widely distributed on northern coasts from Greenland to Norway, Great Britain and the Mediterranean and has also been reported from South Africa.

6. *T. pellucidus* Coe. Intertidal zone; coasts of New England and southward; Monterey Bay to San Diego, Calif.

7. *T. polymorphus* (Renier). Intertidal zone; northern coasts of Europe; Mediterranean; Aleutian Islands, Alaska, British Columbia to Monterey Bay, Calif.

8. *T. sexlineatus* Griffin. Intertidal zone; Alaska to southern California.

9. *Carinomella lactea* Coe. Intertidal zone to 20 meters; Monterey Bay to San Diego, Calif. Burrowing form, found on sandy shores of boys.

Family Carinomidae

10. *Carinoma mutabilis* Griffin. Intertidal

[1] Contributions of the Scripps Institution of Oceanography, University of California, new ser., no. 216. Received October 27, 1943.

zone to 40 meters; British Columbia to Gulf of California. Burrows on sandy shores of bays.

Family Cephalothricidae

11. *Cephalothrix major* Coe. Intertidal zone; southern California.

12. *Procephalothrix spiralis* Coe. Intertidal zone to 20 meters; New England; Alaska to San Diego, Calif.

Order HETERONEMERTEA

Family Baseodiscidae

13. *Baseodiscus delineatus* (Delle Chiaje). Widely distributed in both Northern and Southern Hemispheres; Mediterranean to Cape Verde Islands; Mauritius; Bermuda; Barbados; Fiji Islands; Chile; Japan; Gulf of California.

14. *B. delineatus* var. *curtus* (Hubr.). Coextensive with the preceding.

15. *B. mexicanus* Bürger. Gulf of California; west coasts of Mexico and Panama; Galápagos Islands; intertidal zone to 100 meters; among shells and corals.

16. *B. princeps* Coe. Alaska to Puget Sound; intertidal zone and off shore to depths of 50 meters or more; off Goloi Island, Alaska, 50 meters; off Oshima, Japan, 250 meters (*Albatross*); Sea of Japan 135–290 meters (*Albatross*); off Ose Saki, Japan, 260 meters (*Albatross*); south of Hokkaido, Japan, 340 meters (*Albatross*). This species was also found by Yamaoka (1940) in the intertidal zone at Hokkaido, Japan, but was erroneously assigned by him to *B. curtus* Hubr. Supplementing the original description by Coe (1901) it has since been ascertained that some individuals of *B. princeps* on the coast of Alaska and in Puget Sound have the lateral margins and ventral surface of the head white or colorless. These white areas disappear when the head is strongly contracted.

17. *B. punnetti* Coe. Monterey Bay to Gulf of California, Mexico; intertidal zone to 380 meters.

18. *Zygeupolia rubens* (Coe). Intertidal zone to 50 meters; southern New England and southward to North Carolina; Monterey Bay, Calif., to Ensenada, Mexico.

Family Lineidae

19. *Euborlasia maxima* Coe. Gulf of California.

20. *E. hancocki* Coe. Coasts of Mexico, Panama, and Peru; 17 to 100 meters.

21. *E. nigrocincta* Coe. San Francisco Bay, 20 meters; Monterey Bay, Calif., to Ensenada, Mexico; intertidal zone to 30 meters.

22. **Euborlasia variegata**, n. sp. This species was represented in a collection of nemerteans from Alaska by a headless fragment about 160 mm in length. The width of the body is 7 to 10 mm and the thickness 6 to 8 mm. The body is somewhat flattened in the middle intestinal region but becomes rounded posteriorly. The posterior extremity is rounded and without caudal cirrus.

This specimen is put on record because of the remarkable and distinctive coloration of the body. In spite of preservation in alcohol for about two years the color pattern is still conspicuous, consisting of an orange ground color, overlaid with bluish black longitudinal bands and transverse rings. On some portions of the body the black pigment covers most of the dorsal and ventral surfaces but in other portions it is confined to narrow rings which encircle the body. Several adjacent rings become wide and confluent on dorsal or ventral surface, or both, giving the appearance of broad, interrupted longitudinal bands connected by narrow lateral rings. This specimen represents a ripe female and the abundance of ova presumably influences the color pattern to some extent.

Sections show that the bluish-black pigment is confined to the cutis and that the pattern is formed by the relative thickness of the pigment layer, which is thin in certain areas and much thicker and denser in others. The epithelium and the muscular layers are colorless or yellow and the intestinal epithelium and ova deeper yellow or orange.

This specimen (U.S.N.M. 20633) was dredged at a depth of about 30 meters in Port Graham, Cook Inlet, Alaska, by Dr. Waldo L. Schmitt in connection with the Alaska King Crab Investigation, 1941.

23. *Lineus bilineatus* (Renier). Northern coasts of Europe; Mediterranean; Madeira; South Africa; Alaska to San Diego, Calif.

24. *L. flavescens* Coe. Southern California to Gulf of California, Mexico.

25. *L. geniculatus* (Delle Chiaje) (=*L. digueti* Joubin). Intertidal zone to 30 meters; Gulf of California; west coasts of Mexico and Panama; Mediterranean and Black Seas; west coast of Africa.

26. *L. pictifrons* Coe. Intertidal zone; Puget

Sound to coast of Mexico.

27. *L. ruber* (O. F. Müller). Intertidal zone to 10 meters; circumpolar; Siberia; northern coasts of Europe; Mediterranean: Madeira to South Africa; Greenland to southern New England; Alaska to Monterey Bay, Calif.

28. *L. rubescens* Coe. Monterey Bay to San Diego, Calif.

29. *L. torquatus* Coe. Coast of Alaska to San Francisco Bay.

30. *L. vegetus* Coe. Found in the intertidal zone beneath stones and decaying vegetation in estuaries, harbors and bays, as well as in crevices of rocks and among corallines and other growths exposed to the full force of the surf; sometimes above middle of intertidal zone; occasionally in brackish water. Commonly associated with dead barnacles and mollusks; feeds on ciliates and other small organisms, living or dead. San Francisco Bay, Calif., to Ensenada, Mexico. Reproduces asexually by fragmentation as well as sexually by fertilized eggs; has remarkable regenerative capacity.

31. *Micrura alaskensis* Coe. Intertidal zone; Prince William Sound, Alaska, to Ensenada, Mexico; Japan.

32. *M. impressa* (Stimpson). Bering Strait.

33. *M. nebulosa* Coe. Dredged at depths of 120–900 meters off the coasts of Alaska and California.

34. *M. nigrirostris* Coe. Among kelp holdfasts and other growths on rocks at low-water mark and below; southern California.

35. *M. olivaris* Coe. Monterey Bay and off San Francisco, Calif.; low-water mark to 120 meters.

36. *M. pardalis* Coe. Intertidal zone; Monterey Bay, California, to Ensenada, Mexico.

37. *M. verrilli* Coe. Intertidal zone and below; Alaska to Monterey Bay, Calif.

38. *M. wilsoni* Coe. Intertidal zone to 35 meters; Monterey Bay, California, to Gulf of California.

39. *Cerebratulus albifrons* Coe. Muddy flats between tide marks and below to depths of 100 meters or more; Alaska to San Diego, Calif.

40. *C. californiensis* Coe. On muddy shores and in bays to depths of 35 meters or more; Puget Sound to Gulf of California.

41. *C. herculeus* Coe. Bering Sea, coast of Alaska to central California and off the coast to depths of 60 meters or more.

42. *C. lineolatus* Coe. Muddy bays, southern California, Gulf of California and west coast of Mexico; intertidal zone to 70 meters or more.

43. *C. longiceps* Coe. Intertidal zone; Yakutat Bay, Alaska; off Oshima, Japan, 250 meters.

44. *C. marginatus* Renier. Sandy and muddy shores to depths of 100 meters; circumpolar; Norway to Madeira; Greenland and Labrador to Cape Cod; Alaska to San Diego, Calif.; Bering Sea (62°N. 173°W.), 70 meters; Japan.

45. *C. montgomeryi* Coe. Coast of Siberia; Bering Sea; Alaska to Monterey Bay, Calif.; Behm Canal, Alaska, 150–400 meters; Moss Cape, Belkofski Peninsula, 40 meters; off Hokkaido, Japan, 600 meters.

46. *C. occidentalis* Coe. Alaska to San Francisco Bay; off central California, 120 meters; Cold Bay, Alaska, 40 meters; Bellingham Bay, Wash., 20 meters; intertidal zone, Prince William Sound to Puget Sound.

47. *C. signatus* Coe. Bering Sea, 110 meters.

48. *Diplopleura vivesi* Joubin. Gulf of California, Mexico.

Order HOPLONEMERTEA
MONOSTYLIFERA
Family Emplectonematidae

49. *Emplectonema bürgeri* Coe. Intertidal zone to 500 meters; Alaska to Monterey Bay, Calif.; off Vancouver Island, 300 meters; Chatham Strait, Alaska, 500 meters; off Oshima, Japan, 250 meters.

50. *E. gracile* (Johnston). Northern coasts of Europe to Madeira; Aleutian Islands and coast of Alaska to Ensenada, Mexico; Chile; Kamchatka to Japan; intertidal zone to 100 meters. In many localities on northern coasts the most abundant of all species of nemerteans.

51. *E. purpuratum* Coe. Aleutian Islands.

52. *Nemertopsis gracilis* Coe. Intertidal zone and below; Puget Sound to Ensenada, Mexico.

52a. *N. gracilis* var. *bullocki* Coe. Intertidal zone; coast of central California.

53. *Paranemertes californica* Coe. Monterey Bay, Calif., to Ensenada, Mexico; in sandy and muddy bays.

54. *P. carnea* Coe. Intertidal zone; Alaska to Puget Sound.

55. *P. pallida* Coe. Intertidal zone; Alaska.

56. *P. peregrina* Coe. Commander Islands; Aleutian Islands, Alaska, to Gulf of California; Kamchatka to Japan. Intertidal zone and below, among mussels and other growths; often very abundant.

57. *Dichonemertes hartmanae* Coe. Intertidal zone; San Diego, Calif.

Family Carcinonematidae

58. *Carcinonemertes epialti* Coe. Commensal parasite on crabs of the genera *Portunus*, *Pugettia* and *Euphylax*. Monterey Bay to San Diego, Calif.; Peru.

Family Ototyphlonemertidae

59. *Ototyphlonemertes spiralis* Coe. On sandy shores of bays; San Diego, Calif.

Family Prosorhochmidae

60. *Prosorhochmus albidus* (Coe). Intertidal zone; Monterey Bay, Calif., to Ensenada, Mexico.

61. *Oerstedia dorsalis* (Abildg.). Intertidal zone and below; circumpolar; Norway to Mediterranean; Madeira; Nova Scotia to Florida; Puget Sound to Gulf of California.

Family Amphiporidae

62. *Zygonemertes albida* Coe. Intertidal zone; British Columbia to Ensenada, Mexico.

63. *Z. thalassima* Coe. Intertidal zone; Alaska.

64. *Z. virescens* (Verrill). Intertidal zone and below to depths of 120 meters; Bay of Fundy, New England and southward to North Carolina; Puget Sound to Gulf of California.

65. *Amphiporus angulatus* (Fabricius). Circumpolar; Greenland; Davis Strait; Labrador to Cape Cod; Bering Strait; Bering Sea; Aleutian Islands and Kamchatka to Japan; Alaska; British Columbia; Puget Sound and southward to Point Conception, Calif.

66. *A. bimaculatus* Coe. Intertidal zone; Alaska to Ensenada, Mexico; off San Diego, Calif., 250 meters; Okhotsk Sea, 140 meters.

67. *A. californicus* Coe. Intertidal zone to 80 meters or more; coast of southern California.

68. *A. cruentatus* Verrill. Intertidal zone to 80 meters or more; New England to Florida; Puget Sound to San Diego, Calif.

69. *A. flavescens* Coe. Monterey Bay, Calif., to Ensenada, Mexico.

70. *A. formidabilis* Griffin. Bering Island, Aleutian Islands, coast of Alaska and southward to Monterey Bay, California.

71. *A. fulvus* Coe. Intertidal zone to 85 meters; southern California.

72. *A. gelatinosus* Coe. The absence of the proboscis in the type specimen did not permit a satisfactory description of this species (Coe, 1905). Specimens collected by the U.S. Fish Commission have since become available for study and in these the proboscis proves to be typical for the genus *Amphiporus*. The basis is pear-shaped, of moderate proportions and not quite so long as the rather slender central stylet which measures 0.16 to 0.18 mm in length in an individual 150 mm long. There are four pouches of accessory stylets, with 4–5 stylets in each, and 15 to 17 proboscidial nerves. The body contains a larger proportion of gelatinous tissue than has been reported for any other species of the genus. Length of body 100 to 150 mm; width 10 to 16 mm.

Dredged at a depth of about 300 meters southwest of Kodiak Island, Alaska; at 400 to 450 meters in Clarence Strait; at 40 meters near Port Townsend, Wash., and at 130 meters in Uraga Strait, Japan.

73. *A. imparispinosus* Griffin. Intertidal zone to 50 meters; coast of Siberia, Bering Sea, Alaska to San Diego, Calif., and Ensenada, Mexico. Abundant in many localities.

73a. *A. imparispinosus* var. *similis* Coe. Differs from the typical form in having 2, instead of 3, pouches of accessory stylets. Puget Sound to Ensenada, Mexico.

74. *A. macracanthus* Coe. Dredged in the Arctic Ocean off the northern coast of Alaska.

75. **Amphiporus maculosus,** n. sp. This species is distinguishable from others of the genus by the reddish brown spots and blotches on the dorsal surface. Another species, *A. nebulosus* Coe, has the dorsal surface more nearly covered with confluent dark brown spots and blotches, while in *A. maculosus* they are widely separated. *A. nebulosus* has 18 to 25 ocelli on each side of head but in the only specimen of *A. maculosus* available for study ocelli could not be detected. The stylet basis in *A. nebulosus* is much swollen posteriorly and about as long as the stylet, while in *A. maculosus* it is only moderately enlarged posteriorly and much longer than stylet. The nephridia, caecal diverticula and proboscis show minor anatomical differences.

Body moderately slender, narrowed posteriorly; head with inconspicuous oblique grooves. Length of type specimen 36 mm, width 3 mm, thickness 2 mm after preservation.

Color of body pale gray, with numerous reddish brown spots and blotches on dorsal surface; head without spots. These markings vary

in size from dots to large blotches, usually separated by much larger spaces without pigment. The spots in this specimen cover less than one-third the dorsal surface. Ventral surface pale gray.

Ocelli could not be detected either in the specimen cleared in oil or in the sections.

Proboscis sheath extends entire length of body. Proboscis large, stylet basis pear-shaped, about twice as wide posteriorly as anteriorly and twice as long as the posterior diameter. Central stylet two-thirds as long as basis. In this specimen there are 18 large proboscidial nerves. Each of the two accessory stylet pouches contains three stylets.

Cerebral sense organs large, situated anterior to brain, each with a relatively large canal leading anteriorly to an oblique groove on lateroventral surface near tip of head. Cephalic glands voluminous.

Nephridia extend anteriorly as far as posterior borders of cerebral ganglia. Intestinal caecum extends forward on ventral side of pylorus but terminates some distance posterior to brain; caecal diverticula short, not reaching brain. Gonads more numerous than intestinal diverticula; oviducts open ventrolaterally.

The single known specimen was collected at Lagoon Reef, St. Paul Island, Bering Sea. Type, U.S.N.M. no. 16797.

76. *A. nebulosus* Coe. Intertidal zone; coasts of Alaska and Japan.

77. *A. occidentalis* Coe. Dredged at depths of 70 to 170 meters off the coast of Washington.

78. *A. pacificus* Coe. Dredged at depths of 70 to 180 meters in the Bering Sea and off the coasts of Washington and California. In two specimens from Bering Sea the ocelli are more numerous than figured by Coe (1895) and are arranged in two groups on each side of head. The anterior, marginal, group on each side consists of about 10 large and 8 smaller ocelli, while the posterior, cerebral, group has about 8 large and 6 small ocelli. Most of the cups of those in the marginal groups are directed forward and those of the cerebral groups backward.

79. *A. paulinus* Punnett. Pribilof Islands, Bering Sea.

80. *A. punctatulus* Coe. Intertidal zone; Catalina Island, Calif.

81. *A. rubellus* Coe. Intertidal zone to 200 meters; coast of southern California.

82. *A. tigrinus* Coe. Intertidal zone; British Columbia and Puget Sound.

Family Tetrastemmatidae

83. *Amphinemertes caeca* Coe. Dredged with tunicates at a depth of 5 meters; Kodiak Island, Alaska.

84. *Tetrastemma aberrans* Coe. Intertidal zone; coast of Alaska.

85. *T. bicolor* Coe. Shallow water; Kodiak Island, Alaska.

86. *T. bilineatum* Coe. Intertidal zone; San Diego, California.

87. *T. candidum* (Müller). Circumpolar; Greenland and Norway to Madeira; South Africa; Labrador to New England and southward; Alaska to Ensenada, Mexico.

88. *T. nigrifrons* Coe. Intertidal zone; Puget Sound to coasts of Mexico and Costa Rica; Japan.

89. *T. quadrilineatum* Coe. Intertidal zone; Monterey Bay, Calif. to Ensenada, Mexico.

90. *T. reticulatum* Coe. Southern California; intertidal zone.

91. *T. sexlineatum* Coe. Dredged at a depth of 35 meters near San Clemente Island, Calif.

92. *T. signifer* Coe. Intertidal zone to 10 meters; Monterey Bay to San Diego, Calif.; locally common on kelp holdfasts.

POLYSTYLIFERA REPTANTIA

Family Drepanophoridae

93. *Drepanophorus crassus* (Quatrefages). Dredged at depths of 2 to 100 meters or more; Arctic Ocean; European coasts; tropical Pacific islands; Cape San Lucas, Mexico; Panama; West Indies; Peru.

94. *D. ritteri* Coe. Dredged at depths of 50 to 300 meters off coast of southern California.

POLYSTYLIFERA PELAGICA

Family Planktonemertidae

95. *Planktonemertes agassizii* Woodworth. Bathypelagic at depths of 1000 meters or more off coasts of Panama and Ecuador.

Family Nectonemertidae

96. *Nectonemertes pelagica* Cravens and Heath. Bathypelagic at depths of 100 meters or more off coasts of California and northern South America.

Family Pelagonemertidae

97. *Pelagonemertes brinkmanni* Coe. Bathypelagic at depths of 600 meters or more. Bering Sea and off coasts of Alaska, Aleutian Islands and Kamchatka.

Family Dinonemertidae

98. *Dinonemertes mollis* Coe. Bathypelagic at depths of 600 meters or more; off coast of Mexico.

Order BDELLONEMERTEA
Family Malacobdellidae

99. *Malacobdella grossa* (Müller). Commensal in various species of bivalve mollusks. Northern coasts of Europe, Mediterranean; Nova Scotia to Chesapeake Bay; Puget Sound to California.

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Obituary

The premature death of CHARLES ELMER RESSER, on September 18, 1943, at the age of 54, deprived the ACADEMY of one of its newest members. Born in East Berlin, Pa., on April 28, 1889, young Resser grew up in country underlain by the Cambrian rocks and fossils to which he devoted much of his later life. He graduated from Pennsylvania State Teachers College in 1912 and in 1913 received his A.B. degree from Franklin and Marshall College. Here he came under the influence of the inspiring geologist, Justin Roddy, who imparted his enthusiasm for fossils and the earth sciences to his student.

In 1914 Dr. Resser became assistant to Charles D. Walcott, great student of the Cambrian. Working under this mentor for some years, he received his paleontological training and his wide knowledge of the Cambrian period and its fossils. In 1915 he became assistant curator of paleontology in the U. S. National Museum and associate curator in 1923. From 1929 until his death he held the title of curator of stratigraphic paleontology.

Although Dr. Resser's practical training was received under Walcott, he continued his more formal education at Princeton and George Washington Universities, receiving the Ph.D. degree from the latter in 1917. In 1915 he was appointed part-time instructor in geology and geography in the George Washington University and was advanced to assistant professor in 1923. This position was relinquished in 1932. Dr. Resser also taught geology in the University of Maryland for several years.

After the death of Walcott in 1927, Dr. Resser became custodian of the Cambrian collections and devoted most of his time to research on the fossils and stratigraphy of this period. He made field investigations in the Great Basin, Rocky Mountains, and Canadian Rockies and in his later years made several trips into the southern Appalachians to study Cambrian strata. Two visits were made to Europe for the same purpose. This concentrated effort on one period of time gave Dr. Resser a knowledge of Cambrian fossils, particularly trilobites, which enabled him to see relationships between strata in this country and abroad that had hitherto been unsuspected. His untimely death abruptly terminated several ambitious programs that would have brought to fruition the results of his life's studies.

Although Dr. Resser's scientific interest lay in Cambrian fossils, he was perhaps equally devoted to the service of his fellow men through his activities in church and educational affairs. He was long time president of the District of Columbia Sunday School Association, a member of the Board of the Central Union Mission, and chairman of the Board of Trustees of the Washington City Church of the Brethren. He was a member of the Board of Trustees of Bridgewater College and was active in behalf of other colleges of his church.

Foremost of Dr. Resser's honors was the D.Sc. conferred by his alma mater, Franklin and Marshall College, in 1934. He was a fellow of the Geological Society of America and a member of Sigma Gamma Epsilon.

In 1908 Dr. Resser married Anna M. Evans, who, with his two children, Harold and Mrs. Helen R. Yates, survives him. By his death Christianity has lost a devoted servant and geology and the ACADEMY a member who was not granted time to fulfill his best promise. His affable disposition and kindly ways will be missed by all his friends.

G. A. COOPER